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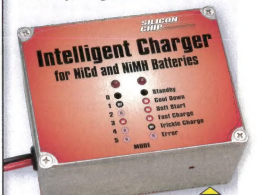

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Publisher's Letter

Generating your own electricity during blackouts

The Publisher's Letter in the June issue certainly tickled the fancy of a number of readers, as they postulated how the "anti-islanding" feature of grid-tied inverters could be circumvented. We have published a few of their letters in the Mailbag pages this month. Of course, the reason for wanting to circumvent the "anti-islanding" feature is to trick grid-tied inverters into generating power when the grid is blacked out. But the grid-tied inverter "knows" when the grid is up and only generates power at that time, provided of course, that the solar panels are in sunlight.

Well, the anti-islanding feature is pretty much bullet-proof, as it is meant to be, so that the inverter cannot feed power to an otherwise dead grid and possibly be a hazard to people working on the power lines. It cannot be tricked by simply connecting it to the output of standard DC-to-AC inverter with a sinewave output. Part of the anti-islanding feature is to measure the impedance of the grid and also test whether its frequency can be "pulled" slightly high or low. When the grid is connected, this isn't possible.

Some readers think that perhaps the anti-islanding feature of a grid-tied inverter is provided by a little module which can be disabled. We think that is highly unlikely and instead, it is part of the overall software. The only way to get around it would be to get into the software and modify those lines of code which provide that feature. Sounds simple but I will bet that even getting into the software would take some doing. All of which means that those grid-tied inverters which are available quite cheaply via the internet are pretty much useless for this purpose, unless you are a software guru.

Still, the fact that the topic appears to be of considerable interest has us thinking as well. Why not produce an inverter which will run from the same solar panels as a grid-tied inverter? This would have to cope with the same high input voltages as the grid-tied inverter but be completely independent and would generate power when the grid-tied inverter was effectively disabled.

Really, that is not too hard and we just happen to have the basis of a such a design already in our project archive. Which one is it? The answer is the 230VAC Induction Motor Speed Controller that we featured in 2012. Apart from some initial teething problems which led to the H-bridge module and current sensing resistor failing in a rather noisy fashion on some pump loads, it has now proved to be quite a reliable design, especially when driving 3-phase induction motors.

So how does that help us? In effect, the Induction Motor Speed Controller contains a complete high-voltage DC-to-AC inverter, albeit one in which the output frequency can be shifted over quite a wide range to enable induction motors to be controlled. As it stands, it can accept around 340V DC (eg, from a solar panel array) and it will produce around 2kW at 230VAC. It would be relatively simple to configure as a free-standing general-purpose inverter.

Unfortunately, producing such an inverter is only part of the story if you want it to power your household. You would have to able to completely isolate your household wiring from the grid and then decide which circuits would be powered and so on. That would all need to be done by a licensed electrician and the whole exercise is not likely to be simple or cheap.

However, there is now a better solution: a hybrid grid-tied inverter which has battery back-up. This enables you to control the amount of power you export to the grid and instead use it to charge batteries which can power the inverter when the sun goes down and more importantly, let you generate power when the grid is down.

So that clearly is the answer but it means that all those thousands of existing solar panel installations can only run at night or when the grid is blacked out by having the inverter changed to a hybrid type. At the moment though, that is a really expensive solution.

Leo Simpson

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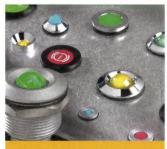

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MAILBAG

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Better batteries won't save solar energy

Everyone who owns a car, truck, tractor, quad bike, bobcat, forklift or other mobile machine is hoping that the fortune being wasted on green energy may produce just one real benefit – better batteries. We want batteries that are cheap, light weight, charge quickly with no losses, last forever and store a large quantity of energy. Nothing close to that is on the market yet.

But better batteries will not make solar energy a competitive source of uninterrupted grid power. The solar power received at any point on Earth's surface varies continuously from zero at dawn, peaks at mid-day, and falls back to zero by dusk. It varies from summer to winter and can fall suddenly at any time if clouds, dust or snow obscure the sunlight.

On a clear cloudless day, solar energy can be collected at constantly varying rates over about 10 sunny hours. To use solar alone to produce 24/7 steady grid power, batteries must supply power for the 14 hour shadow zone (which often covers peak demand). Assuming no losses in the charging/discharging process and no clouds, solar energy plus batteries will deliver a steady supply of less than 20% of peak generating capacity over a 24 hour period. This means that over 80% of energy collected during any sunny window must be devoted to charging the batteries and is not available for immediate consumption.

However, there are also cloudy days, sometimes for weeks at a time. To cover this possibility, many more batteries (and solar panels) will be needed for the same guaranteed steady output. Better batteries can never change this.

Of course green enthusiasts will say: "We'll charge the batteries using excess power from wind turbines and solar collectors when it's available and use the stored energy to smooth out the natural fluctuations." This may work on the doodle pad of some green academic but imagine the complications, costs and losses in all these AC/DC conversions and the risks of grid failure when trying to meet power demand schedules by combining two variable, unreliable intermittent energy sources. And because of the diluted nature of solar/wind energy, huge areas of land must be blighted to collect significant quantities of energy.

If we had perfect batteries, it would be cheaper and simpler to use cheap base-load coal, nuclear, gas or hydro power to charge them and then use the charged batteries – instead of expensive peaking generators – to handle peak power.

Or with perfect batteries, a householder could use off-peak power to charge his batteries and then use battery power at peak-price times. With widespread use, this could allow all electricity to be supplied cheaply from low-cost reliable base-load generators.

Better batteries are worth striving for but they will never make solar energy grid-ready.

Viv Forbes,
Rosewood, Qld.

Clouds can increase solar panel output

I refer to the article entitled "Home Solar Panel Electricity: Is it worth it?" in the May 2015 issue. I suggest that the reason the circuit breaker needs to these sources even before considering insolation; it cannot possibly be less than the latter or the Earth would still be incandescent. Solar output varies with the 22-year reversal cycle of the Sun's magnetic field and probably in other as yet unidentified ways.

Other factors also affect insolation. Cycles in the Earth's orbit with periods in the order of tens of millennia are well documented and the Earth's albedo is affected by variations in ice and cloud cover.

Human activities may well be responsible for an acceleration of global warming but to imply it is the sole cause displays a lamentable lack of knowledge of geological history.

Tony Ellis,
Tithi Bay, NZ.

Earth has been warming for thousands of years

I don't know where Col Hodgson (Mailbag, May 2015) gets the idea that "for thousands of years the Earth's energy balance has been in a state of equilibrium with global temperatures remaining relatively constant" but he is seriously mistaken. The Earth has, in fact, been warming for the last 20,000 years. Were it not so, much of Europe, Asia, and North America, together with the higher latitude areas of the southern hemisphere, would still be blanketed by ice and sea levels would now be some 90m (300 feet) lower.

Meteorological records cannot always be taken at face value. Many meteorological stations were established on the outskirts of settlements which have subsequently expanded to engulf them. This can produce an apparent upward trend as urban temperatures are typically about 3°C higher than rural temperatures. Even stations remaining in rural areas may have been affected by local changes in land use such as deforestation or intensification of farming.

Mr Hodgson's claim that "the heat loss is around half a watt per square metre less than the heat energy input (solar) . . ." is also seriously flawed, as it ignores the substantial heat outflow from the Earth's core and mantle (sustained largely by radioactive decay) and tidal effects which also represent a significant heat source.

Clearly radiative heat accounts for

Headphone amplifier for hearing impaired

I would be very interested in such a device. I have aids in both ears and they have different equalisation profile needs. Some people have problems in one ear and not the other. The equalisation would need to be separately adjustable in both channels.

My TV does not have a headphone outlet and I suspect this is a growing trend. To get around this problem, I use the optical output into a Jaycar AC1631 DAC. This then feeds to a Philips SHC8535 wireless headphone.

The amplifier would need to fit between the Jaycar and Philips devices. At the moment, I have no capability to do any equalisation/compensation as I need to remove my aids when using the headphones. All I can do is wind up the volume on the headphones.

Bob Denton,
via email.

be larger than the specified 20A one is not increasing panel efficiency as temperature drops. The evidence is in the curves of Fig.1, on page 38.

According to this, the current peak lasted only tens of seconds but the panel temperatures simply cannot change that rapidly. The cause is simply that in the broken cloud situation described, the panel is receiving insolation direct from the Sun (through the break in the clouds) and indirect insolation, reflected from clouds. My own observations have indicated that output can be up to 50% above direct sunlight in these circumstances.

Cold conditions can help in that the peak will be higher but the proximate cause is the sunlight reflecting from clouds being added to direct sunlight.

John Denham,
Elong Elong, NSW.

Bionic eyes & robotic vision

I read the June Publisher's Letter with some interest. I have limited knowledge of the interaction of solar inverters with the mains other than the fact that they need the presence of mains power to operate.

Assuming that there is no control signal being issued from the distribution network to permit the inverters to work, I would like to pose the following. Could the inverters be tricked into operation with a battery and DC-to-AC inverter with sinusoidal output? With the mains isolated and all of the appliances (particularly the hot water system) turned off, an inverter is used to inject 240VAC into the local circuit. Would the solar inverters start operation?

Theoretically, they should and with a small load permanently connected, the system should be stable. However,

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Mailbag: continued

Orientating solar panels to the west can work well

Thanks for printing my letter about off-grid operation in the Mailbag pages of the May 2015 issue. I hope it encourages others who have had success doing the same to write in and those who failed to write in about the short comings of their venture.

I have some further information to add which may be of interest to some readers about the placement of solar panels. I have found that putting the solar panels on the western side of a gable roof provides the best outcome over east and north for the following reasons.

I have found that at sunrise, although the panels are faced well away from the sun on a 30° sloping roof, there is still about 25-35% output on hazy or overcast days due to scattered light. On clear, bright, sunny mornings, there is no noticeable output until after 9.00am local time then it rises, reaching full power at about 11.00am local time. This is quite workable as when the battery voltage is low from overnight this will bring the voltage up with a low current. Then when the battery voltage has risen and the panels reach maximum output there is no problem with over-current which would happen if they were facing east. It's also when very little power is used in the household.

Current limiting would be a must if they faced east with optimal power available. The other benefit is that from about 10.00am to sunset you have a good power output and some time before sunset is when you are likely to be at home, using power. Also the batteries "go to bed" in a higher charge state than they would if the panels were facing east or north.

David Francis,
Kilburn, SA.

it is always a tricky exercise to connect two systems together when both have feedback control. If the idea will work, then it is possible that all of the existing solar installations can be used when the mains is off.

There has been quite a number of superb articles of general interest to complement the projects and other sections of SILICON CHIP. The June 2015 issue continues with articles on the Tesla car and PowerWall battery plus the Bionic Eye. They make enjoyable reading. However, the Bionic Eye article is of most interest to me.

Although I have a reasonable knowledge of our visual system, I have learnt a number of things. More so, vision is one of the most difficult areas in the development of autonomous robots and this article gives a sense of this difficulty.

When one considers the number of light receptors and processing neurons, it must become apparent to anyone that imitating this process is a major undertaking. I particularly like the resolution comparison where a photo of a car is shown at different resolutions. Using our own ability to recognise the car, it should be evident that it is possible to use a low-resolution camera for robotic vision without resorting to high-resolution cameras which need huge computing power.

George Ramsay,
Holland Park, Qld.

Comment: a grid-tied inverter cannot be tricked into operation by an external 50Hz inverter – see comment below.

Anti-islanding protects power line workers

I read with interest the June 2015 Publisher's Letter regarding the anti-islanding feature of grid-connected inverters. I agree with Leo Simpson that it is a shame the inverter cannot power your house during a blackout. The idea of using a contactor to isolate the home-owner's system would be part of the solution, however nothing is ever as simple as it seems in electronics or life for that matter.

Grid-connected inverters do not have their own 50Hz timebase like a standalone inverter. This serves two purposes. First is the anti-islanding feature to protect line workers and the public from fallen power lines etc. The second purpose is to synchronise the inverter's output waveform to that of the incoming mains. This is of utmost importance in any parallel generating system as generators or inverters not synchronised can act as series short-circuited supplies with massive fault currents. It only takes around 100A to weld metal. Imagine the damage caused by shorting a grid network capable of delivering a fault current of 10,000A (these fault currents are quite easily achieved in suburban areas).

So for the scheme to work you would need to use a contactor to disconnect the inverter as you described then have a simulated sinewave fed into the inverter's monitor circuitry to get it to run. A detailed study of the particular inverter circuit diagram would be required to ensure you don't destroy your sinewave oscillator by connecting it to the wrong point. When the mains finally comes back on line, you would want say 10 seconds dead time to disconnect your oscillator to enable the inverter to again use the incoming mains as a timebase.

I hope this information is useful and I thought I had better write in to warn readers of the possible dangers of trying this scheme. Perhaps inverter manufacturers may design this feature into future designs but for existing inverters the above issues would need to be considered.

Geoff Coppa,
Emerald, Qld.

Comment: as outlined in detail in a letter in the Mailbag pages of the July 2011 issue, it is simply not possible to trick a standard grid-tied inverter to work when the grid is blacked out. The inverter would undoubtedly need re-programming to remove the "anti-islanding" features and then, as noted in the Publisher's Letter, a contactor would be required to totally isolate the domestic solar system from the grid.

Tesla's PowerWall battery could pay for itself

I liked the Publishers' Letter in the June 2015 issue. I would comment that the system should be set up so that the Tesla PowerWall is charged during the day and any excess power would then be put into the grid. During the night the system would be set up to use only the power from the Tesla PowerWall unit until it is flat and then draw power

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4G mobile interferes with digital TV reception

A few years ago when the analog TV was switched off and the digital signal was boosted, I decided to try mounting my old TV antenna in the roof space. The cockatoos had been giving the antenna a bit of grief, so it was worth a shot. After removing a section of sarking and replacing it with builder's polythene, the set-up worked very well.

Living in Coledale south of Sydney, we get two transmitters, Broker Nose and Knights Hill, and the signal was good from both. Then we had those awful storms in April that hit Sydney and the Illawarra. The picture started to pixellate which under the circumstances was to be expected. Eventually the storms subsided but not the pixellation.

I checked the antenna and the amplifiers and they all tested OK. Luckily, I had a visit from my daughter, who, looking at her phone said, "Hey Dad. You've got 4G here!" Then the penny dropped – could this be 4G interference causing the pixellation?

Looking at the options in Jaycar, I saw that I could go for a 4G/LTE filter (Cat. LT3062) for $14.95 or a new UHF phased array antenna with an inbuilt filter (Cat. LT3138 for $74.95). I went for the complete antenna and it worked perfectly, with no pixellation. It would be a good idea if the phone providers announced the roll-out of their 4G coverage and the possibility of it causing interference with TV reception.

Julian James,
Coledale, NSW.

Mailbag: continued

from the grid, as necessary.

You would do this because, if I remember correctly, you are only paid $0.07/kWh as the grid feed-in tariff and you pay something like $0.33/kWh for any power you draw from the grid. In other words, put the least amount of power into the grid and only use power from the grid if necessary. You may also be able to use your Tesla PowerWall power during the peak power period when they charge more. The Tesla PowerWall would then pay for itself.

Roderick Wall,
Mount Eliza, Vic.

Comment: it is too early to say just how well the PowerWall could be integrated into a typical domestic solar panel and inverter installation. It is unlikely to be at all compatible with existing domestic grid-tied installations.

Harmonic & intermodulation distortion

I was interested in a reader's letter published in the Mailbag pages of September 2014 issue, concerning how a valve amplifier with 0.3% distortion was more revealing of detail than a transistor amplifier claiming to have only 0.005% distortion. I would like to make the point that these distortion figures are usually obtained in a test rig where the amplifier is driving a more or less pure resistance rather than the complex impedance of a normal multi-driver loudspeaker and crossover.

So one wonders what the distortion performance of these amplifiers is actually like driving loudspeakers, especially considering that a valve amplifier will probably have an output transformer to "buffer" the load.

In addition, there is no mention of the intermodulation distortion performance of these amplifiers. Perhaps the transistor amplifier produces copious amounts of intermodulation distortion when driving the loudspeaker load which produces a "fog" of high-order harmonics that obscure the subtle detail? I have often thought that people pay so much attention to the distortion performance of amplifiers in test rigs that they tend to forget that a loudspeaker is far removed from a test rig and that the real-world performance of any amplifier is likely to be much worse than the clinical test results in the lab would suggest.

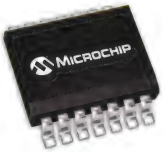
Phil Taylor,
Casula, NSW.

Comment: as we noted in a comment on that reader's letter, perhaps the Yamaha solid-state amplifier in question may have had much higher distortion at low levels and this was why the valve amplifier apparently revealed more sonic detail. However, without being able to run comparative tests on both amplifiers, it is simply not possible to make an objective comparison.

As a general comment, all amplifiers produce more distortion when driving loudspeakers than with resistive loads but that comment applies doubly to valve amplifiers; if they are poor with resistive loads, which is usually the case, they are worse with loudspeakers. Nor does the output transformer "buffer" the load and in fact it is the

Smart Lights Are Better Lights

Modern LED lighting applications require more than just the capability to be turned on and off. Designers need a solution that offers digital control to smooth dimming, as well as color temperature tuning, usage-based lifetime prediction and networked communication for monitoring and control. Also don't forget the challenge of complying with changing efficiency standards.



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Mailbag: continued

Limited corrosion prevention measures in solar installation

The Publisher's Letter in the May 2015 issue had some interesting comments on solar roof installations. When the installers arrived to install the system on my roof, I asked what measure were being used to prevent corrosion caused by the aluminium solar mounting on the galvanised steel roof. They produced some rubber isolation blocks that were impregnated with carbon and some rubber washers on the Tek screws that were also carbon impregnated and no insulating sleeve on the Tek screws.

Needless to say the installation was delayed until the correct non-conductive materials were forthcoming, together with an insulation check procedure. The interesting comment was "this is the way we have been doing hundreds of houses". So yes, the issue is real.

Alan Bothe,
Manly, Qld.

major limitation in obtaining better performance since its phase shifts cause amplifier instability if feedback is too high.

For the record, we have measured some of our amplifiers with simulated loudspeaker loads in the past and they still perform very well. In fact, we will make a point of featuring this sort of measurement in our next high-quality amplifier design.

As far as intermodulation is concerned, we seldom bother to measure it these days; if harmonic distortion is very low, so is the intermodulation. As a corollary of that, since harmonic distortion in valve amplifiers is usually quite high, intermodulation is often bad.

This gives the lie to the common belief that because valves amplifiers tend to have even-order harmonic distortion, they sound more musical. If they have lots of any harmonic distortion, as is common, intermodulation will be equally bad and will give particularly unpleasant results on complex orchestral and choral music.

A device to combat child death in hot cars

According to *USA Today*, an average of 38 children have died in hot cars in the USA every year since 1998. There are many heartbreaking stories why these fatalities occur but it is all too easy to forget the risk to a child left in a car!

My husband and I were fortunate enough to prevent a possible disaster last Christmas. Our family was enjoying festivities on a 6-acre property in western Queensland. We knew that we needed to keep close tabs on our three lively children at all times, due to the high speed adjoining road and the two dams on the property. We did not consider our unlocked vehicle a risk factor.

For a brief period that day our 2½ year old son disappeared from our view, so my husband did a quick look in the immediate area that he was playing in before we decided to head straight to the dams in the hope he hadn't decided to cool off down there. The temperature that day was 40 plus degrees but the temperature in our vehicle was far, far hotter. We were very fortunate that our son has hair as white as snow and was spotted in the back seat of the vehicle on our way to the dams.

You see, when a child gets into the back of our car, the child safety locks engage! In temperatures like that, a child will become disorientated very quickly, making it impossible for them to make clear decisions to remove themselves from the vehicle as their thermo-regulatory systems are not properly developed and warm at a rate 3-5 times faster than an adult. We were very fortunate that we found him quickly.

That near tragedy led us to design and invent a device to combat the risk of hot car entrapment death and injury to a child, animal or invalid – the Detectivator. Our Detectivator will also fit well into the emerging car dash and security camera markets, as well as offer all cars the ability to act as their own WiFi hotspot. The Detectivator acts to monitor the interior of a turned-off car and when motion is detected will send the registered owner an alert signal via conjoined application. This not only gives the alert but transmits GPS information, temperature information and a snap-shot image of the vehicle's interior! We are also hoping that the installation of our device will be supported by the auto insurance companies offering discounted premiums, as it also works as a fully functioning dash camera!

The development costs of this Australian-designed and manufactured device are quite extensive even prior to embarking on a kick-start campaign, so people can support our cause at www.gofundme.com/detectivator

We are seeking investors to help bring this important piece of technology to market. Most of all, we are embarking on this campaign to raise awareness of the risk a car interior can be on a hot day! Please keep your car locked and make sure you are aware of your children's whereabouts at all times if other unlocked cars are present.

Taleese Penna,
Tashla 369 Pty Ltd – www.tashla369.com.au

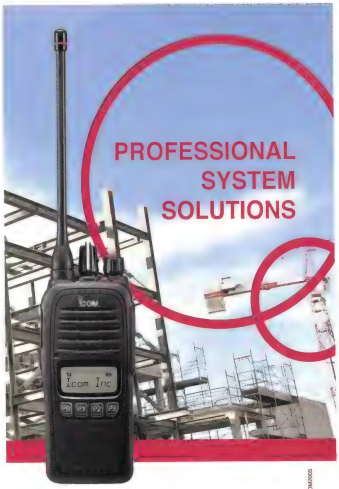
Using GPS SatNav to measure train speed

I refer to the letter from Ray Chapman of Pakenham in the Mailbag pages of the June 2015 issue, concerning the use of a GPS SatNav to measure the speed of trains on which he is a passenger.

The May 2015 edition of *Railway Digest* (Vol 53, No 5) included an article by Malcolm Simister called "Train timing-schedules, speeds and spies" in which he advises that he successfully used a free app, called DigiHUD, on his smartphone. He also mentions that there are other apps available and it is just a matter of choosing one. However, Malcolm found there was no perfect way to measure the speed and briefly described some problems that may be encountered.

I have a dedicated GPS device installed in my car to

ICOM



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WWW.ICOM.NET.AU

Mailbag: continued

Notes on adjusting mechanical vibrators

With reference to the Vintage Radio article in SILICON CHIP, May 2015 entitled "The AWA Radiola 523-M: the last vibrator-powered radio", a few misconceptions about vibrators should be set straight. The statement "A vibrator . . . opens and closes a set of contacts at a fixed frequency of 50-150 times per second, depending on the particular circuit it's used in" is not correct. The frequency of operation has nothing to do with the circuit configuration. It is a mechanically-determined frequency which is a function of the period of oscillation of the reed, which is determined by the stiffness of the metal and the mass of the "bob" on the top of the reed. It has a fixed frequency of oscillation, which for MSP/Oak vibrators was 110Hz.

The statement "It's either a double-pole or 4-pole switch . . ." is also not correct. In fact, it is either a single-pole double-throw switch (non-synchronous type) or a double-pole double-throw switch (synchronous type). The two poles of the synchronous vibrator are normally connected together but an independent-pole type (known as "split-reed") was available if required.

Finally, towards the end of the article, it is stated that the B+ voltage is down to 75V, instead of 90V, after the contacts had been cleaned. After polishing the contacts, they must be readjusted, to maintain the energy conversion efficiency. The correct setting is when contact closure time on each side is 40%±5% of the total period. The only satisfactory way to do this is by viewing the switching waveform on an oscilloscope. This is the way the vibrators were adjusted during manufacture by AWA.

For information on this timing adjustment, refer to the Radiotron Designer's Handbook (Fourth Edition) page 1205. The attached photograph shows the actual final test and adjustment facility in the vibrator manufacturing section at AWA's Ashfield factory, with the oscilloscope in the background. The "dwell time" of the contacts was also indicated on analog meters on the panel (the operator doing the contact adjustment is a very young Ross Stell, in 1953).

Ross Stell,
Kogarah, NSW.

monitor speed. It is mounted on the dashboard in a position well-exposed to receive the signal and I have found it to be reliable and accurate. Out of curiosity, I installed the DigiHUD app on my phone and tried it out in the car, a Mitsubishi Pajero, while my wife drove on a trip to Newcastle. The speed shown on the app varied from the fixed device by one or two km/h and lagged it by one or two seconds.

However, it did not appear to matter where in the car my phone was; it still indicated the speed, albeit with the limitations already mentioned. I had expected the performance of the app to deteriorate in positions where it was shielded by the steel body panels. This got me thinking that the app may have been responding to the phone signal, which was quite strong, rather than the satellite signal but I have no way of verifying whether or not this was so.

David Williams,
Kincumber, NSW.

AM pocket radio has poor treble response

With reference to Ask SILICON CHIP, May 2015 concerning a request for a headphone amplifier for the hearing-impaired, I think it's a great idea. I am 68 years old with pretty bad high frequency hearing loss (can't hear the eight top keys on a piano) and have used high-end, expensive hearing aids on and off for years. I regularly walk in the morning, listening to ABC radio with earphones and a small AM receiver. I really can't hear the consonants in speech. The words "bill", "fill" "sill" "till" etc all sound the same to me. I have to do a lot of interpolation from sentence structure to get meaning.

Anyway, for some time now I have imagined a SILICON CHIP project in one of two forms, as follows: (a) an article describing how to modify a typical AM/FM shirt-pocket receiver to give high-frequency boost in reverse proportion to typical older male hearing loss and (b) an interface between a small radio and the earphones to provide a similar effect. Ideally, there would be a switch to select between "mild", "moderate" or "severe" high frequency hearing loss. I'm pretty sure there are "typical" male hearing loss curves available from audiologists.

By the way, I'm not being sexist. I believe there *is* such a thing as typical male hearing loss, different from that which the fairer sex experiences in older years. Also, it's not worth bothering with digital radio reception when walking. There is no comparison to the total coverage one gets from AM no matter what the surroundings.

Ben McGee,
East Hills, NSW.

Comment: if you are listening to AM radio with earphones, you are compounding your listening disadvantage, as far as consonants are concerned, because the audio bandwidth of a shirt pocket radio will be poor, typically rolling off above 3kHz, and this will be exacerbated by the high-frequency response of cheap earphones.

If you have a smartphone and a good pair of earphones, you would get much better audio via the ABC's audio streaming service. Naturally, there's an app for it.

Headphone amplifier for hearing impaired

In response to the query from T. S., of Tauranga, NZ regarding a headphone amplifier project for the hearing-impaired, I would like to offer my opinion. I have been a very satisfied user of Blamey and Saunders hearing aids for roughly a year now; necessary to compensate for age-related hearing loss, especially at higher audio frequencies.

If I want to listen to music or internet radio without disturbing my other half, I use a pair of over-ear headphones while still wearing the hearing

aids. This I find absolutely satisfactory, once the program audio has been suitably adjusted to a comfortable level.

On most TV programs the hearing aids work fine on their own. However, there are a few programs where accents and varying audio levels can be a problem in which case a pair of over-ear wireless headphones are resorted to. Hence my conclusion is that such an amplifier is probably not necessary and could be a pain to adjust or calibrate.

Richard Kerr,
Millfield, NSW.

New version of electrocardiograph wanted

I successfully built the electrocardiograph described in the February 2005 issue of SILICON CHIP and ran it on a Windows XP machine. However, any attempt to run it on a laptop with Windows 7, 8 or 8.1, were complete failures for fairly obvious reasons.

Unfortunately, reprogramming for these later Windows versions is beyond my limited programming capabilities, so could I suggest resurrecting the project with updated software for its operation?

I now find that the necessary Windows 8.1 FTDI VCP driver is available for download and registers in Device Manager as working properly. So that leaves the problem centring around the Comdlg32.ocx file which is shown as "not correctly registered: a file is missing or invalid" when I try to run ECGsampler.

I am sure that there are other older readers who also have this useless piece of perfectly good hardware sitting on a shelf and like me, an occasional look at their ticker behaviour is more than justified.

So I strongly suggest another look at the electrocardiograph project to either reissue it completely or if that isn't feasible, then a software update as you may find a surprising number of readers still interested in the original project.

D. J. Omond,
Adelaide, SA. SC

Solar power is good for the power companies

We have solar power on our house, and I don't understand the arguments that I've been reading in SILICON CHIP. We had it fitted late in the piece, just as our 43rd Parliament was deciding it was not the direction that the country needed to take and so we received a discount based on the RECs but no generous feed-in tariff.

Now our house is very efficient (it's the fridge, measure the power consumption of your fridge!) and so my "Watt's Clever" power meter is telling me that we are currently pumping around 1kW into the grid and for that power, the electricity company gives us 6c per kilowatt-hour. We live up near Brisbane, so we pump in a lot of ergs during a long sunny day.

It's not so good at night, because the panels produce no power at all – don't bother writing in to argue, I went out and checked. That means that for the night, we are buying power at 32c per kilowatt-hour and the power company is oinking all the way to the bank.

But there's more! Everyone on the grid pays a supply charge for the pleasure of being connected. For us, it's around $1.10 per day, so even if we used no power at all, we would still have to cough up around $100 per quarter.

So who benefits from that little arrangement? We do to some extent, because the panels power our entire house during the day but the power company is demonstrably doing just fine too, thank you. The solution that I adopted is obvious, and left as an exercise for the class, and the next step is to get rid of the supply charge as well.

It's no wonder the energy authority propaganda machine is running at full speed.

Ned Stojadinovic,
via email.

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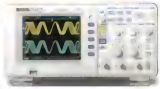

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ELECTRONICS MEETS

The driving force in boating is now electronics, with new products being released every month. To see where boating electronics is heading, Kevin Poulter visited the recent Sanctuary Cove International Boat Show and the Gold Coast Marine Expo.

All boats, from tinnies to super yachts, can benefit from electronic innovations, enhancing safety, ease of use, comfort and convenience.

For example, anyone with an active EPIRB (Emergency Position Indicating Radio Beacon) who gets into difficulties on the water can be seen by a central rescue service thousands of kilometres away. Or they could call anywhere globally on a satellite mobile.

Skippers can also view the way nautical miles ahead, even in the dark and see the bottom, with the fish displayed. Here's a round-up of some of the most interesting products.

There were drones, of course! At a boat show? Yes, there are many marine and marina applications, from filming super yachts for web display to commercial video production to security surveillance.

In fact Peter Blake, the owner/Director of UAS Services Australia won a Churchill scholarship to study drones and techniques in major countries and now shares his knowledge and services with law enforcement agencies and boating clients, including operators of multi-million - dollar super yachts.

UAS Services Australia can supply drones for almost any budget but more importantly, the expertise to use them properly. See www.uaservicesaustralia.com

Eye in the sky: what used to take thousands of dollars a day with a real helicopter can now be achieved for a fraction of that, using a drone such as shown here . . .

THE QLD BOAT SHOW

Great drone footage of super yachts can be seen at http://uasservicesaustralia.com/super_yachts/

S-E Queensland photographer, John Hildebrand of Aerial HotShots, was also at the same stand. John flies drones for aerial photography.

For lower levels, he raises a camera attached to a long pole to achieve a bird's eye view.

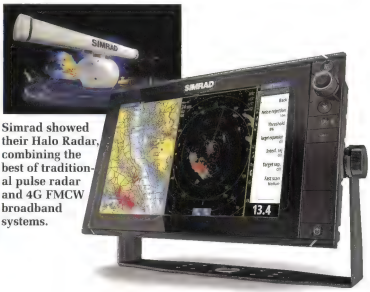
His pilot's license is very helpful for flying drones and applications include photographing floor by floor views from high-rise towers under construction or even at planning stage. See www.aerialhotshots.com.au

. . . and here's a drone's-eye-view (OK, the GoPro helped!) of a marina. Whether it's for security, for advertising . . . the uses are endless!

New radar technology

Radar manufacturers have long been researching ways to reduce warm-up time, increase range, near and far, as well as increasing clarity and reducing emissions, which can affect people or equipment too close to the unit.

Combining the best characteristics of traditional pulse



Simrad showed their Halo Radar, combining the best of traditional pulse radar and 4G FMCW broadband systems.

and 4G FMCW broadband radar systems, Simrad Halo Radar uses pulse compression technology to deliver an unprecedented mix of close and long-range detection. It has a "warm-up" time of just 16-25 seconds, precise target definition and low clutter.

The culmination of ten years' work by Simrad Yachting's Australasian research and development hub, Halo Radar provides target detection as close as six metres – well within pulse radar's short-range "blind spot" – while offering an exceptional long-range performance up to 72 nautical miles.

It even has the ability to easily pin-point birds from miles away using Halo's dedicated bird-finder mode.

As any keen fisherman is well aware, birds diving into the ocean are a good indication that the fish are running.

In Dual Range mode, Halo Radar functions as two radar systems in one – monitoring two distance ranges simultaneously with independent displays, controls, 10-target MARPA target tracking and no compromises in detection at either range.

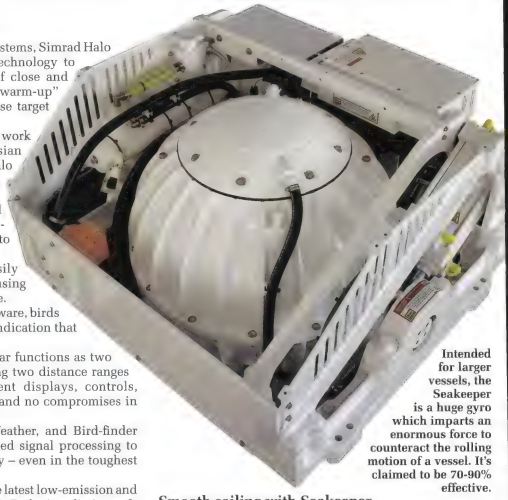
Custom, Harbour, Offshore, Weather, and Bird-finder modes tune Halo Radar's advanced signal processing to ensure targets are depicted clearly – even in the toughest environmental conditions.

In addition, compliance with the latest low-emission and radiation standards means that Halo Radar is radiation-safe to people within the swing circle of the array on all models and is safe to run in anchorages and marinas.

Power requirements are low, just 40W average in no wind, 150W at maximum wind velocity, while in standby mode power consumption is only 6.5W. With such low power consumption,12V or 24V operation and availability in 3, 4 and 6-foot open arrays, Halo Radar is ideal for vessels of all sizes, including smaller powerboats where open array radar may not have been practical previously.

Halo Radar connects via Ethernet, with a bulkhead-mounted interface box below deck. For more information about Halo Radar or the entire line of Simrad Yachting marine electronics, see www.simrad-yachting.com

Simrad in "birdfinder" mode: where dere's boids, dere's (usually) fish!



Intended for larger vessels, the Seakeeper is a huge gyro which imparts an enormous force to counteract the rolling motion of a vessel. It's claimed to be 70-90% effective.

Smooth sailing with Seakeeper

Anyone who has been seasick or tossed around in a boat rolling in heavy seas will lust after the Seakeeper. Available for boats over 10m, it is basically a huge gyro, sized according to the boat's weight. The Seakeeper 35 suits vessels up to 140 tonnes (two units can be installed in larger vessels).

The unit has a heavy flywheel that spins at high speed in a near vacuum, with its angular momentum producing a gyroscopic righting torque to counteract any boat roll. The result is an angular momentum of 35,000 Newton-metre seconds (NMs) and an anti-rolling torque of 73,000 Newton-metres.

Built for large boats, it weighs 1720kg. Installation has to take into account the stresses from the huge torque of the Seakeeper, as it works to hold the boat vertical against the action of swell.

Unlike fin-type stabilisers which rely on forward motion through the water to work, Seakeeper works equally well when a boat is motionless or is being subjected to roll from swell or other boat wakes.

To achieve maximum stability, the Seakeeper 35 gyro has a 65-minute spool-up time to its rated 5,150 RPM and is normally spun up using 5kW from shore power before setting sail. Seakeeper claims to achieve 70 to 90 percent roll reduction, with some reports indicating total removal of rolling for boats in moderate waters.

Naturally, an on-board diesel generator needs to be kept running while ever Seakeeper is in use.

Australian Seakeeper owner Bruce Scott reported: "The Seakeeper has done everything the supplier said it would do, including improving the stability at speed." More at www.twindisc.com

FUSION's new MS-UD750 marine stereo which internally docks, charges and controls iPhones and other devices. The photo below shows the flip-up screen . . . flipped up!

Marine entertainment

New Zealand-based FUSION entertainment systems are sold worldwide and specified as original equipment on many boats, caravans and RVs. FUSION released 17 new marine products, including the feature-packed MS-UD750 marine stereo, which internally docks, charges and controls Apple products including the iPhone 6, other smart phones and media devices. Boaters who still prefer CDs can choose a CD/DVD unit with options including smart phone and other device capability.

FUSION-Link enables connection of FUSION entertainment systems to multi-function displays from Simrad, Garmin, B&G, Hummingbird, Lowrance, Raymarine and Furuno.

Other new features include Pandora radio control, Bluetooth and App control via Bluetooth or Wi-Fi.

FUSION's multi-zone control has independent level and balance control plus subwoofer line outputs to four zones. This enables custom systems to suit all vessels from trailer boats to motor yachts.

Their Signature audiophile speakers compare favourably to home hifi speakers, with the advantage of water and harsh environment resistance. FUSION speakers can operate with simple panel mounting in many boats, however they perform best in an enclosure, which can be as simple as a sealed box.

For more information on FUSION-Link and compatible Furuno displays, FUSION or its entire line of marine entertainment products, see your FUSION dealer or telephone FUSION Australia on 1300 736 012, New Zealand/Pacific: 09 369 2900. www.fusionentertainment.com.

Icom's IC-M423G marine transceiver has integrated GPS

This new offering from Icom has a wealth of features. A rotary selector and directional keypad provide quick and easy access to all the functions, with a high contrast white back-lit LCD for clear indication.

Built-in noise-canceling reduces background noise up to 90% in RX and 30% in TX.

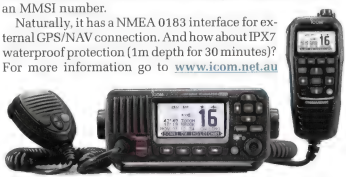
The IC-M423G has a built-in 10W amplifier for voice or foghorn to an external PA speaker. DSC watch function monitors Ch. 70 (DSC channel) activity, even while receiving another channel. DSC functions include distress, individual, group, all ships, urgency, safety, position request/report, polling request and DSC test calls.

The built-in GPS receiver shows your current position, date/time and can be used for DSC calls. The GPS data source is selectable from internal and external GPS.

The optional white back-lit COMMANDMIC makes it convenient for using the IC-M423G from a separate cabin or tower. All functions of the IC-M423G can be controlled from the COMMANDMIC and it can be used as an intercom with the IC-M423G.

When connected to the optional MA-500TR Class B AIS transponder, the AIS target call function allows you to make an individual DSC call without having to manually input an MMSI number.

Naturally, it has a NMEA 0183 interface for external GPS/NAV connection. And how about IPX7 waterproof protection (1m depth for 30 minutes)? For more information go to www.icom.net.au



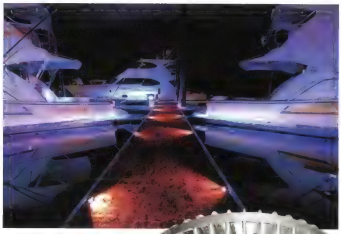
No need for separate marine radio and GPS units: the ICOM IC-M423G has both. Great to return to that favourite fishing spot!

LED lighting for boats

With their greater efficiency and much longer life, LEDs have almost completely supplanted incandescent lighting in boats and the good thing is that there's a comprehensive range of lighting made by Aqualuma on Queensland's Gold Coast.

Their through-hull lighting range, with one-piece polymer housings and no lenses or seals, is patented in 127 countries. These hull lights attract fish and other marine life, effectively turning the water beneath the vessel into an underwater aquarium. Plus they really make the boat stand out. Aqualuma also makes boat deck and flood lighting, plus LED pathway lighting for docks.

Also seen at the SCIBS boat show was Aqualuma's 125W LED Lightsource-R Highbay lamp. This LED fitting replaces



LED lighting makes a lot of sense for boats, with lower current drain for much more output. Aqualuma is a local (Gold Coast) manufacturer who also had LED lighting to keep marina dock and pathways safer at night.

a 400W metal halide light, delivering an output flux of 24,000 lumens and is rated for a minimum of 100,000 hours at 25°C.

It is water resistant to IP66, has instant on/off and comes with 5-year warranty. More info at www.aqualuma.com.

Garmin's widescreen Chartplotter/Sonar Combo

Garmin's latest offering is a mouthful, the GPSMAP 7412xsv, 12-inch Multi-touch Widescreen Chartplotter/Sonar Combo. It is designed for sports fishermen, cruisers and sailors. The unit has a worldwide base map, built-in 1kEdual CHIRP sonar plus CHIRP DownVü and CHIRP SideVü scanning sonar. This enables the display of low/high, med/high or low/med resolution modes on the screen at the same time and it provides nearly photographic sonar images of fish, enhancing the ability to distinguish between game fish and shoals of bait-fish.

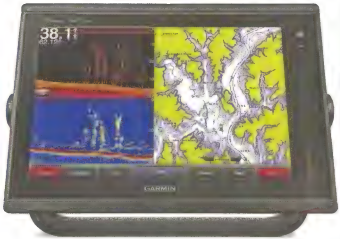
The GPSMAP 7412xsv supports radar, autopilot, instruments, multiple screens, FUSION-Link, sensors, remote sonar modules, digital switching, thermal cameras, with GRID rotary knob, joystick and keypad control, and more.

Dropping up to 5,000 way-points — and finding your way back to them is quick and easy. Garmin Helm allows viewing and control of all functions from a compatible smartphone or tablet. When using an iPhone or iPad, you can even record a movie of your chart plotter screen to share with friends and family.

With BlueChart Mobile, a free app downloaded from the App Store, you can plan marine routes on your iPad or iPhone then wirelessly transfer them to your Garmin chart plotter.

Garmin's Auto Guidance allows you to enter the location you want to go to and it searches through relevant charts to create a safe virtual pathway on the display that helps you avoid low bridges, shallow water and other charted obstructions en route.

If you get into difficult sea conditions, simply tapping



Garmin's Chartplotter/Sonar combo unit offers a 12-inch multi-touch display with a wide range of inputs.

the SOS button on the chart-plotter's touchscreen display will cause your networked Garmin VHF radio to automatically tune to the Channel 16 emergency frequency and a list of possible situations (fire, man overboard, etc.) will be displayed. Once the applicable choice has been selected, the screen will provide a Coast Guard approved VHF radio distress call script, along with the ship's current GPS coordinates – thus saving time and assuring the best possible outcome.

More information can be found at https://goo.gl/oMa5B6.

TrackSAT marine satellite TV reception

As boats roll and rock constantly, a marine satellite TV receiver needs to have outstanding lock and reaction to the desired signal. At the Sanctuary Cove Boat Show this was clearly demonstrated, as the unit was energetically rocked in demonstrations.

TrackSAT's UltraTrack UT100 satellite TV receiver has automatic satellite search and skew control, a programmed satellite database and the ability to edit satellite data. And as you would expect, it has a 3-axis servo stabilisation and built-in GPS for fast lock on.

Boaters can catch the latest news, weather or sports games. There are two feeds of Satellite TV available in Australia, Foxtel Pay TV and the VAST FTA Network. TrackSAT can also provide a Free to Air Satellite Digital Satellite TV Receiver as an option. This allows reception of all free-to-air channels through the Australian Government controlled VAST network. More info at www.tracksat.com.au

3-axis stabilisation helps keep the TrackSAT locked on to satellite TV signals despite the swell!

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By Geoff Graham

The Pawsey Supercomputing Centre

Just what is a supercomputer? How does it work? What do you use it for? We take you inside the Pawsey Supercomputing Centre to meet Magnus, the fastest and most powerful supercomputer in the Southern Hemisphere.

FROM THE OUTSIDE, the Pawsey Supercomputing Centre appears rather modest, just a low building set into the hillside. Located in Technology Park in the leafy suburb of Kensington in Perth, Western Australia it houses two supercomputers, a host of supporting computer systems and a huge data-storage facility.

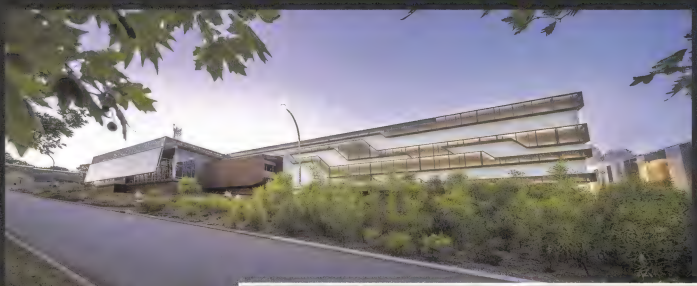
The statistics are impressive. The smaller supercomputer called Galaxy can perform at 200 teraflops – a teraflop is a million million floating point calculations per second. So it's no slouch.

However the star is Magnus, a Cray XC40 supercomputer capable of 1.5 petaflops. A petaflop is a thousand million million floating point calculations per second and this makes Magnus the most powerful public research computer in the southern hemisphere. There may be a more powerful computer in existence (who knows what ASIO have hidden behind their walls) but this is definitely the fastest publicly acknowledged computer.

Everything here is big; the storage systems can store 70 petabytes of data with an expansion capacity to 100 petabytes. The power consumption is around 900MW and water is drawn from underground to keep the supercomputers cool.

In the beginning

The Pawsey Supercomputing Centre was named after pioneering Australian radio astronomer Dr Joe Pawsey. It started life in 2009 with an $80 million grant from the Federal Government, in part to support Australia's push to be the southern hemisphere's site for the Square Kilometre Array radio telescope (see SILICON CHIP, December 2011 & July 2012).



The Pawsey Supercomputing Centre in Technology Park, Perth, Western Australia houses the fastest supercomputer in the Southern Hemisphere. The building was designed to merge with the landscape and reflect the geosciences, a major user of the supercomputers. Photo credit: Pawsey Supercomputing Centre

The centre opened in 2013 and still processes a lot of data from the radio telescope but the rest of its capacity (about 75%) is dedicated to the five partners operating the centre (the CSIRO and four WA universities) and researchers in Australia in general.

In some respects the Pawsey Centre is unique because they not only provide the computer facilities but they also train and help researchers to get the best results from the system. The centre also has a number of systems dedicated to visualising the data so that researchers can watch the result of a simulation and that makes understanding the data much more intuitive.

For example, a geologist would normally take core samples in the field and then analyse these to try to map the ore deposit. By using the Pawsey supercomputers, they can go much further and calculate the distribution of the sample results through the geology of the region. In addition, by using 3D glasses along with the visualisation technology, they can stand inside the ore deposit and look around to see how it is distributed.

Inside Magnus

So just what is a supercomputer?

This is Magnus, the fastest computer in the Southern Hemisphere. The cabinet artwork is by Margaret Whitehurst and pays homage to the centre's close connection to the north-west of Western Australia. It has been designed to reflect "the ground below", in reference to geoscience, one of the areas the supercomputing centre supports most closely. Photo credit: Pawsey Supercomputing Centre.

These days, it is basically just a massive set of processors that work on a problem in parallel. In the case of Magnus, that is 35,712 processing cores.

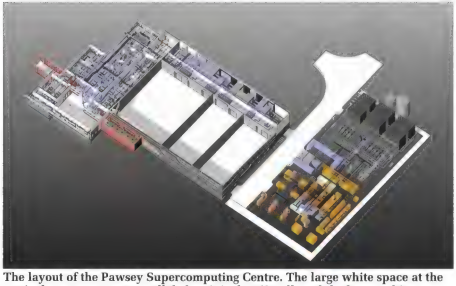
The processors are standard Intel Xeon E5-2690V3 Haswell units. Each processor has 12 cores running at 2.6GHz and two processors together with some local memory make a node, which is the basic computing element. Four of these nodes are physically mounted on a blade which is a large plug-in module and is the replaceable part in the case of a component failure. Magnus consists of eight cabinets with each cabinet holding 48 blades for a total of 1488 nodes (35,712 processor cores).

You might think that you could build a supercomputer like this using a lot of standard desktop motherboards but that wouldn't work when scaled to the numbers required by Magnus for scientific workloads. Removing heat is one issue but also getting the data to each processor requires a special network.

Interconnecting the nodes

In Magnus, the nodes are interconnected with 4km of high-speed optical fibre and copper, making a network

Galaxy is the smaller of the two supercomputers. Its primary purpose is to process data coming from the radio telescope arrays (ASKAP and MWA) in the Murchison in the north of Western Australia. When they are running, these telescopes generate an amount of data equivalent to one DVD every two seconds and this data needs to be processed in real time. Photo credit: Pawsey Supercomputing Centre.



The layout of the Pawsey Supercomputing Centre. The large white space at the top is the supercomputer cell, below it is the I/O cell, and the lower white space is the tape cell. Each cell has different temperature and humidity requirements, differences between water cooling versus air cooling, and differences in whether mains power or uninterruptible power is used. The supercomputer cell is primarily water-cooled and on mains power. Photo credit: Pawsey Supercomputing Centre.

capable of an aggregate bandwidth of over 100,000 gigabits per second. The network (called Aries) runs a special protocol designed to keep latency low.

Local storage for Magnus is three petabytes with a sustained read/write performance of 70GB/s. This is just used for temporary storage with the end results going to a separate 70 petabyte storage system maintained by the centre.

Managing Magnus

Magnus was built by Cray Inc in the USA and two Cray engineers are located permanently on site to help keep the specialised hardware and operating software running smoothly.

Interestingly, the management software for Magnus (called SLURM) runs under Linux. Linux and SLURM run on a specialised processor and are responsible for distributing work to the various compute nodes. So in practice, the researchers and technicians running the supercomputer interact with Linux – originally a hobby project by a young lad in Norway.

Because a supercomputer is a scarce resource (there are not many around) getting time on it takes some effort. The researcher must make a proposal which is assessed by a committee who consider the scientific value of the application and the processing time that it would require.

Once over that hurdle, the program must be prepared and queued for processing. It is rather like the old batch systems of yesterday; you submit the program and data and wait for a processing slot. However, it is worth it – in just one hour, Magnus can do more work than a conventional computer could do in two years.

Using a supercomputer

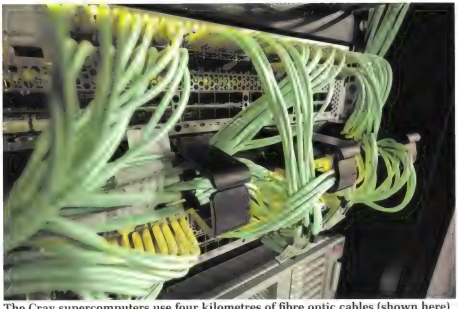
Because a supercomputer is a massively parallel machine it tends to work better at some jobs than others. These include simulations of physical systems, image processing and geophysical mapping.

A typical application that works well is atmospheric modelling. In this, the atmosphere is divided into cubes of a few kilometres in each dimension. Each processor in the supercomputer is allocated the job of simulating the changes in one cube and while it is doing that, the other processors are working in parallel on other cubes.

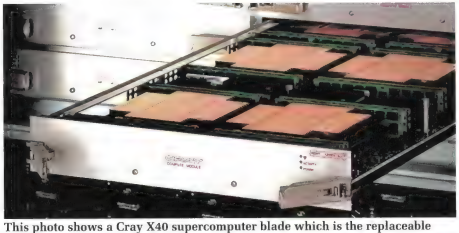
When one processor has finished, its will be allocated a new cube to process. Because there are many, many cubes, all the processors in the supercomputer will be busy for some time. The results of each simulation are then aggregated to gain an image of the whole system.

Similar approaches are used to model ocean currents, star formation, the generation of tsunamis, investigate the electromagnetic structure of matter and more.

Some more novel uses of the Pawsey supercomputers have been sequencing the genome of the cane toad and investigating the porosity of bread. This last



The Cray supercomputers use four kilometres of fibre optic cables (shown here) and copper cables to distribute data to the processing nodes. The network, called Aries, runs a special protocol designed to keep latency low. Photo credit: Pawsey Supercomputing Centre.



This photo shows a Cray X40 supercomputer blade which is the replaceable module in case of component failure. Each blade holds four nodes and in Magnus each node consists two standard Intel Xeon E5-2690V3 Haswell processors with 12 cores running at 2.6GHz. The total number of processing cores on a blade is 96. Photo credit: Cray Inc.

one might sound silly but it is quite important to Australia as the international perception of Australia's wheat is that it is not suitable for bread making.

Researchers at the CSIRO's Food Futures National Research Flagship used X-ray micro-tomography to examine the structure of bread and the resources at the Pawsey Supercomputing Centre to visualise the structure. With the knowledge gained, it is hoped that future research will help improve Australia's standing in this important market.

Another unusual application is the Sydney-Kormoran Project which is processing images from the WWII shipwreck sites of HMAS Sydney and HSK Kormoran. The aim is to provide a moveable 3D image of the two ships resting on the ocean floor for researchers and the public to examine.

Huge amounts of data

With all this processing, there is a lot of data, especially from the radio telescope arrays (ASKAP and MWA) in the Murchison in the north of Western Australia. When they are running, these telescopes generate an amount of data equivalent to one DVD every two seconds and the data needs to be processed and archived in real time.

One supercomputer (called Galaxy) is dedicated to this task, with the data saved onto a sophisticated storage sys-

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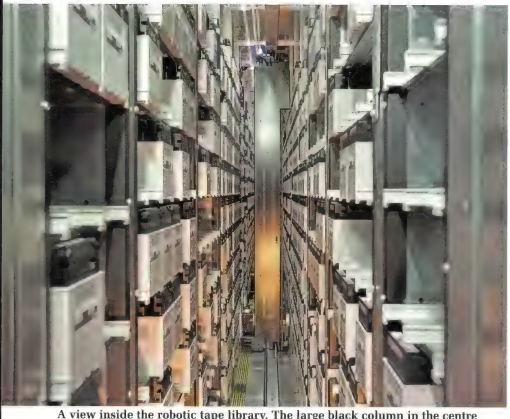


A view inside the robotic tape library. The large black column in the centre is the robotic tape arm. This travels up and down on rails between the tape cartridges on either side, retrieving cartridges and delivering them to tape drives. The robot system is completely automated and looks like a very large disk drive to the supercomputers. Credit: Pawsey Supercomputing Centre.

tem that is also used by Magnus and other systems in the centre.

This storage system looks like a large single disk drive to the rest of the facility but is in fact an array of spinning disks which act as a cache to a large tape library managed by robots. The disks are high-reliability versions of the standard disk drives that we all have in our computers and on their own add up to six petabytes. The operating software distributes the data over the drives so that if one or more fail, the missing data can be reconstructed.

The operating software is also responsible for automatically archiving little-used data to the tape library. This consists of robot arms which retrieve tape cartridges from storage and place them into tape drives so that data can be written and read by the main system. The software keeps track of what piece of data is written onto which tape at what position. In total, the tape system can hold up to 100 petabytes.

All this is transparent to the rest of the system. A researcher could request some data that is recent and it would probably be still held on a spinning disk, so it would be returned immediately. But if they requested some very old data, the chances are that it would have been archived and a robot tape arm would then swing into action to retrieve the right tape and place it in a drive. In that case, there would be a delay of some minutes before the data is returned but other than that it would be no different from reading any other file.

Tapes may be regarded as low technology and many would ask why not just use more disk drives and do without the complex tape system. The reasons are capacity, power and heat. The existing system has a capacity of up to 100 petabytes which would require an unimaginable number of disk drives and even if they were used, the power and cooling requirements would be unsustainable.

Power

The overall supercomputing centre draws about 900MW from the Western Australian grid. You might think that a lot of this has to be backed by a UPS and diesel generators to keep the supercomputers running but that is not so. Some systems are protected by a UPS but the supercomputers are not.

This is because firstly they draw such a huge amount of power that a properly-sized UPS would be prohibitively expensive. The second factor is that, by its nature, a supercomputer does not need to be kept running during a power blackout. It does not store much data and any interrupted jobs can be simply restarted when the power is restored.

The centre does have a system to protect the supercomputers from glitches on the power line though. This consists of a large electric motor driving a flywheel which is in turn connected to a generator. If there is a glitch in the power, the momentum of the flywheel will keep the generator running and insulate the supercomputers from any ill effects.

Groundwater cooling

An intriguing feature of the Pawsey Supercomputing Centre is the cooling used for the supercomputers. Magnus alone generates about 400kW of heat and a cooling system for that heat load would be expensive to provide and operate.

In a world first, the CSIRO Geother-

Gigaflops, Terabytes & More

The basic units used in the supercomputing world are gigaflops, teraflops and petaflops for processing capacity and terabytes and petabytes for storage.

Giga means a thousand million or 10^9, while Tera means a million million or 10^{12} and Peta is a thousand million million or 10^{15}.

A FLOP stands for floating point operations per second. Most scientific computing involves manipulating floating point numbers which is why this measure is used. Note that benchmarking computers is a tricky business and the claimed numbers can vary considerably depending on how someone runs the benchmark or calculates the result.

By way of comparison, a typical dual core processor on a laptop or desktop computer would have a theoretical maximum performance of about 20 gigaflops.

In a world first development by the CSIRO Geothermal Project fresh water is drawn from the Mullaloo Aquifer 100 metres underground to cool the supercomputers. This water is at a constant temperature of 21.5°C and after doing its job is returned to the aquifer at about 24.5°C. Given the size and depth of the aquifer the effect on it is minimal. Credit: Pawsey Supercomputing Centre.

mal Project developed a system whereby cool water is drawn from an underground water body called the Mullaloo Aquifer, about 100m below ground. This water is at a constant temperature of 21.5°C and after being used to cool the supercomputers is returned to the aquifer at about 24.5°C. On a particularly hot day, a second return system is used but the effect on the underground water system is minimal.

To further bolster the system's green credentials, the pumps used to move the water are powered by solar panels on the roof of the centre.

The power savings are significant but the most important factor in water starved Western Australia is the saving of approximately 14.5 million litres of water every year, compared to a conventional system using evaporative cooling towers.

As part of the research involved in this project, it was discovered that the underground aquifer is slowly moving and in a 100 years or more it will have passed from under the supercomputer centre. By then, computers and cooling requirements will have changed so this was not considered a concern.

This system of cooling involved cutting edge research and has attracted world-wide attention. Unfortunately, funding for the group responsible was terminated with the change of government in Canberra and the expertise has dissipated. Such are the ups and downs of a publicly funded organisation. SC

HMAS Sydney which was sunk with all lives in a battle with the German auxiliary cruiser Kormoran which was also sunk during the engagement. The Pawsey Supercomputing Centre is processing photographs of these ships lying on the seabed to create a moveable 3D image for researchers and the public to view.

Driveway Monitor

Pt.1: By JOHN CLARKE

Based on a Honeywell magneto-resistive sensor, this Driveway Monitor provides an audible and visual indication when a vehicle is detected. Alternatively, it can be made to activate a remote-controlled mains switch to turn on lights etc for a preset time.

OUR DRIVEWAY MONITOR will alert you to any vehicle arriving in your driveway and it's equally useful on a farm, detecting vehicles passing through a gate.

Several methods can be used for vehicle detection, including infrared and ultrasonic beam set-ups. However, infrared and ultrasonic beams are prone to false triggering so a typical vehicle detection system relies on the very small changes in the Earth's magnetic field caused the presence of a vehicle. Fig.1 shows a representation of the distortion in the Earth's magnetic field caused by the presence of a vehicle.

Our previous Driveway Sentry units published in November 2004 & August 2012 used a coil of wire to detect changes in the Earth's magnetic field when a vehicle passed over it. This coil could either be laid under the driveway or concealed in the expansion joints, if that was possible. While this arrangement can work well if you are installing a new driveway, you wouldn't want to jack-hammer an existing concrete driveway to lay a cable under it!

Our new Driveway Monitor sidesteps this problem by using a Honeywell magneto-resistive sensor, as used for magnetic field sensing in electronic compasses. It's so sensitive that it doesn't need to be located under the driveway; somewhere alongside the driveway is sufficient.

The magneto-resistive sensor is teamed with a sensitive instrumentation op amp and a PIC microcontroller which outputs a coded 433MHz signal. This is picked up by a companion 433MHz receiver unit with various optional outputs.

Once triggered, the receiver unit flashes a green or red LED and sounds a piezo alarm. It will even tell you which way the vehicle is heading, since a different distinct sound is made by the piezo transducer for each direction, while a third tone indicates vehicle movement in either direction. In addition, the green LED flashes for vehicles entering the driveway, while the red LED flashes for vehicles exiting the driveway.

Alternatively, the LEDs and piezo transducer can be omitted and a couple of reed relays fitted to the receiver PCB instead. These can be used to trigger a UHF remote-controlled mains socket (via its remote), a wireless doorbell remote or perhaps even the remote for a motorised gate opener.

The detector circuitry is installed in an IP65 case (115 x 90 x 55mm) that's dust tight and able to withstand wet weather. This would normally be mounted alongside the driveway, either on an adjacent fence, wall or post.

Power for the detector comes from a single 1.25V AA NiMH cell that's recharged using a solar cell panel (the same as those used with solar garden lights). No mains power is necessary.

On the other hand, if you don't want to use solar power and there is access to undercover mains power, a small 9-12V DC plugpack could be used to recharge the NiMH cell.

The companion receiver unit is housed in a small plastic case and is powered from a 12V DC plugpack. It can be placed where it can be readily heard and seen, if you intend using it purely as an audible/visual indicator. Alternatively, it can be placed out of sight if you intend using it to trigger a remote controlled mains socket or some other device.

Block diagram

Fig.2 shows the block diagram of

The detector PCB carries the magneto-resistive sensor and is mounted in a waterproof case near the driveway (note: prototype PCB shown).

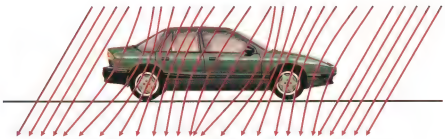


Fig.1: how the Earth's magnetic field is disturbed by a vehicle travelling along a driveway. These disturbances are detected by the magneto-resistive sensor used in the Driveway Monitor.

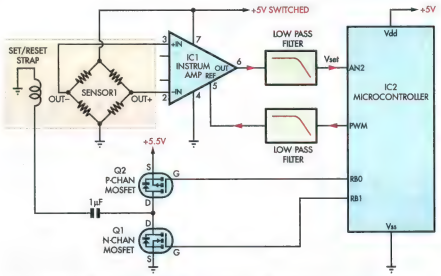


Fig.2: block diagram of the detector circuit. The output from the magneto-resistive sensor (Sensor1) is amplified by differential op amp IC1 which then feeds the AN2 input of microcontroller IC2 via a low pass-filter. IC2 then processes the amplified sensor signal and also drives Mosfets Q2 & Q1 via its RB0 & RB1 outputs to provide set and reset signals to a strap coil in the sensor. In addition, IC2's PWM output applies an offset voltage to the REF input of IC1, so that IC1's pin 6 normally sits at 2.5V (half-supply).

the detector circuit. It's based on the Honeywell HMC1021S one-axis magneto-resistive sensor, instrumentation amplifier IC1, PIC microcontroller IC2 and Mosfets Q1 & Q2.

The magneto-resistive sensor is essentially a Wheatstone bridge of four resistors (which are affected by magnetic fields). The bridge is connected across a 5V supply and a change in the local magnetic field changes the resistor values so that the voltages at the sensor's outputs move up or down. This shift in the output terminals is monitored by differential instrumentation amplifier IC1.

Its output feeds microcontroller IC2 via a low-pass filter. If the magnetic field around the sensor changes, the micro sends an appropriately coded signal to a 433MHz transmitter module (not shown on Fig.2).

Strap coil

Each time the sensor detects a large change in the surrounding magnetic field, its magneto-resistors need to be reset by means of an internal "strap coil" which provides a strong magnetic field. Hence the strap coil is subjected to a short reset signal from the micro. And in fact, before a measurement can be made, a "set" signal must also be applied, again by the microcontroller (see the panel on pages 30-31 for further details).

The set and reset pulses appear at IC2's RB0 & RB1 outputs respectively and these drive Mosfets Q1 & Q2. The resulting pulses are fed to the strap resistor via a 1µF capacitor.

Each time IC2 takes RB0 low for a set pulse, Q2 switches on and current flows through the 1µF capacitor and the set/reset strap to ground (0V). The 1µF capacitor charges to +5.5V and Q2 then switches off . The amplified sensor output (Set) is then read at IC2's AN2 input.

Conversely, for the reset pulse, Q1 is switched on when RB1 is taken to +5V. The 1µF capacitor then discharges through the set/reset strap with current now flowing in the opposite direction than for the set pulse. Q1 is then switched off to end the reset pulse and the amplified sensor output (Reset) is again read at the AN2 input.

IC2 then needs to apply an offset voltage to IC1 so that its output at pin 6 normally sits close to 2.5V and thereby ensure that its output swing is symmetrical. IC2 calculates this offset voltage by averaging the readings after the set and reset pulses. It then generates a pulse width modulated signal at its PWM output and this is fed via a low-pass filter to pin 5 (REF input) of IC1.

The PWM signal generated by IC2 switches between 0V and 5V at 7.8kHz. Its duty cycle is automatically adjusted after each measurement to correct for any offset changes from both the sensor and IC1 due to temperature changes.

IC1's output is also low-pass filtered, to reduce any voltage ripple at IC2's AN2 input, due to the PWM signal, to

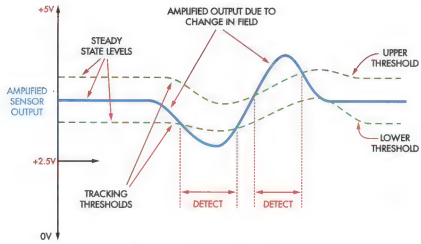


Fig.3: this diagram shows how IC1's pin 6 output changes when a vehicle comes close to the sensor. It either decreases and then rises as the vehicle approaches (as shown here) or it increases and then falls, depending on the orientation of the sensor and the direction of the vehicle. A vehicle is detected whenever the amplified sensor output exceeds the slowly-averaged upper and lower thresholds set by IC2 in response to IC1's steady-state output.

a very low level. This allows microcontroller IC2 to detect voltage changes from the sensor as low as 5mV without being swamped by noise and ripple.

Detecting a vehicle

Fig.3 shows how IC1's output changes when a vehicle comes close to the sensor. As can be seen, it either decreases and then rises as the vehicle approaches or it increases and then falls, depending on the orientation of the sensor with respect to the Earth's magnetic field and the direction of the vehicle.

This enables the microcontroller to determine the vehicle's direction. A linking option on the PCB tells the microcontroller which is the entry direction and which is the exit direction.

IC2 detects a vehicle when IC1's output rises above an internally-generated upper threshold or falls below a lower threshold. These two thresholds are set equidistant above and below the steady-state amplified sensor output.

Main Features

- Remote vehicle detection with adjustable detection sensitivity
- Vehicle detection LED indication
- Vehicle direction detection
- Solar panel and NiMH cell powered
- Transmits vehicle detection via UHF link to the receiver
- Typical UHF range: 200m in open space
- Eight possible UHF transmission identities to allow for multiple Driveway Monitor pairs to be used in close proximity
- Selectable vehicle entry only or exit only detection or both entry and exit detection
- Optional non-directional indication
- Vehicle direction detection setting to cater for detector positioning and driveway orientation
- Over range indication (flashes red & green LEDs in detector unit) alternately.
- Diagnostic setting
- Receiver has audible and visible indication of vehicle detection
- Receiver produces different sounds for exit and entry unless non-direction detection is selected on the detector unit
- Detection sampling rate: typically 300ms
- Set & reset pulses: every 10s

In operation, these upper and lower thresholds track the sensor's amplified output at a slow rate to compensate for any output changes with temperature (as well as slow magnetic field changes) over time. So if the sensor's amplified DC output falls, the thresholds will also fall.

On the other hand, the tracking is slow enough to ensure that any quick changes in IC1's output level (ie, due to vehicle movement) will exceed the thresholds for brief periods. These are shown as the "detect" periods on Fig.3 and when the thresholds are breached, the microcontroller determines that a vehicle has been detected.

Note that in order to conserve the battery, the detector circuit doesn't continuously monitor changes in the magnetic field. Instead, both the sensor and IC1 are powered for a brief period every 300ms and this is when IC2 samples IC1's output.

Circuit details

Now take a look at Fig.4 which shows the full circuit of the detector unit. The top section can be regarded as a more detailed version of the block diagram of Fig.2 but it also includes 433MHz UHF transmitter module TX1, PNP transistors Q3 & Q4 and a switching power supply.

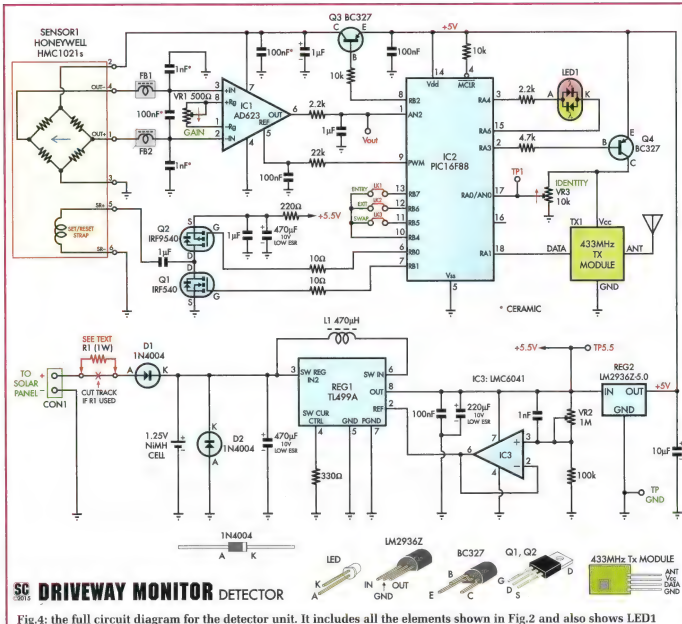
Q3 & Q4 are respectively driven by RB2 & RA3 of IC2 and switch power to the sensor, IC1 and the UHF transmitter module every 300ms, as mentioned above. The switched 5V supply rail from Q3 is decoupled using a 1µF electrolytic capacitor and a 100nF ceramic capacitor.

The power supply uses a TL499A switchmode step-up regulator (REG1), a linear 5V regulator (REG2) and an LMC6041 micropower op amp (IC3). As stated above, it's powered from a 1.25V NiMH AA cell that's topped up by a solar panel.

Alternatively, by cutting a track on the PCB and installing resistor R1, a 9V or 12V DC supply can be used to maintain cell charge if a mains supply is available.

The 5V rail from REG2 directly powers microcontroller IC2 and is switched to sensor 1 and IC1 by Q3 and to the TX1 module by Q4. Sensor 1 draws a current of about 5mA each time it is briefly powered up.

The Out+ and Out- terminals are fed to the IN- and IN+ inputs of IC1 via ferrite beads, while the 1nF bypass



SC 03015 **DRIVEWAY MONITOR** DETECTOR

Fig.4: the full circuit diagram for the detector unit. It includes all the elements shown in Fig.2 and also shows LED1 (for exit and entry indication) and the 433MHz transmitter (TX) module which is driven by IC2's RA1 port. Q3 briefly switches power to the sensor and IC1 at 300ms intervals while Q4 briefly switches power to the TX module, to minimise current consumption. Power comes from a 1.25V NiMH cell topped up by a solar cell. Switching regulator REG1 steps up the voltage to produce a 5.5V rail for Q2 & Q1, while REG2 produces a regulated 5V rail for the rest of the circuit.

capacitors to ground attenuate any RF signals. In addition, a 100nF capacitor bypasses the IN+ and IN- inputs to provide further RF suppression.

IC1 is an Analog Devices AD623 differential amplifier and it draws about 300µA from the 5V supply. Its gain is adjusted using trimpot VR1 and can be varied from about 201 times when VR1 is set to 500Ω (its maximum) up to about 1000 times when VR1 is set to 100Ω.

IC2's PWM signal is fed to pin 5 (REF) of IC1 via a low-pass filter consisting of a 22kΩ resistor and a 100nF capacitor. The filter sets the roll-off frequency to about 72Hz and this effectively removes a considerable amount of the 7.8kHz PWM switching frequency.

However, by itself that is not effective enough to remove sufficient PWM ripple and so IC1's output also has low-pass filtering, using a 2.2kΩ resistor and 1µF capacitor.

Microcontroller IC2 (a PIC16F88) converts the voltage at its AN2 (pin 1) input into a digital value using a 10-bit A-D converter. This gives a resolution of close to 4.9mV. The variation available for the PWM output also has 10-bit resolution, allowing IC1's offset voltage to be set in 4.9mV increments.

Set & reset signals

Mosfet Q2 is driven by IC2's RB0 output and provides the set pulse drive current, while Q1 is driven by RB1 and provides the reset pulse drive for Sensor1's set/reset strap.

This strap is a coil with about 7.7Ω resistance and it produces the high magnetic field required to realign the elements in the sensor along the "easy" axis (see the further description of the

How A Magneto-Resistive Sensor Works

The Honeywell HMC1021S sensor used in this project is a one-axis type. In essence, this means that it only reacts to changes in the horizontal component of the Earth's magnetic field (assuming that it is installed on a vertical PCB).

Fig.5 shows the basic construction of this type of sensor which comprises four identical resistive elements arranged in a Wheatstone bridge configuration.

Each element is basically an NiFe (nickel-iron) thin film that changes its resistance in response to changes in the magnetic field passing through it. Whether an element increases or decreases its resistance with magnetic field strength depends on its orientation and the magnetic field polarity.

Fig.5 shows how the elements in the sensor are arranged. Two diagonally opposite elements are orientated one way, while the other two are orientated in the opposite direction, in the Wheatstone bridge. Because of its sensitivity to magnetic field direction, a magneto-resistive sensor is often called an "anisotropic magneto-resistive" sensor or AMR. The term "anisotropic" simply means directional.

In operation, a supply voltage is applied between the top and bottom of the bridge (ie, between its Vb and GND terminals), so a current flows through the elements. If a magnetic field is absent, the OUT+ and OUT- terminals are both at half supply (ie, Vb/2).

By contrast, if a magnetic field is present, two diagonally opposite elements will decrease in resistance while the other two diagonally opposite elements will increase in resistance. As a result, the OUT+ and OUT- terminals will change voltage by equal amounts but in different directions.

In other words, one terminal will rise above half-supply by a certain amount, while the other will fall below half-supply by an equal mount.

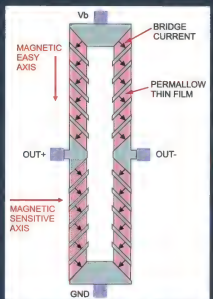


Fig.5: the magneto-resistive sensor consists of four identical thin-film elements arranged in a Wheatstone bridge configuration. Two diagonally opposite elements are orientated one way, while the other two face in the opposite direction.

Offset voltage

That's the basic theory of the sensor operation. In practice though, real sensors have an offset voltage between OUT+ and OUT- in the absence of a magnetic field. That's because when the sensor elements are made, there will always be small variations between them, thereby causing an imbalance in the bridge. In addition, this offset voltage will vary with temperature.

Another problem is that the magnetic domains in the sensor elements can move out of alignment in the presence of strong magnetic fields. Basically, the domains in the elements must be orientated along what is called the "easy" axis and this is the alignment that the magnetic domains are set to during manufacture. Fig.6 shows the general idea.

Correct easy axis alignment is necessary to ensure maximum sensitivity of the sensor to magnetic fields. The most sensitive direction for magnetic field detection is perpendicular (ie, at a right angles) to the easy axis. Any external magnetic field (or a portion of that field) that is not parallel to the easy axis will cause the magnetic domains to rotate away from the easy axis and this alters the resistance of the sensor element.

Conversely, when the magnetic field is removed, the magnetic domains return to their easy axis alignment, provided that the magnetic field does not exceed the specified operating range for the sensor.

Set & reset pulses

In practice, this all means that the sensor will periodically need to be set and reset using a high magnetic field, to realigns the magnetic domains along the easy axis. This set and reset procedure is achieved by applying a pulse current to the strap coil incorporated within the sensor.

The set and reset currents used are opposite in polarity. When the coil is driven with one current polarity, it produces a magnetic field that aligns the domains in one direction along the easy axis. Reversing the current direction through the sensor's coil then aligns the domains in the other direction (ie, it rotates them by 180°).

Fig.7 shows the effect of the set and reset pulses on the sensor's output. As shown, a brief set pulse produces a large output from the sensor, due to the large magnetic field produced by this pulse.

Following the set pulse, the output from the sensor goes down to Vset which is the voltage difference between Out+ and Out- This voltage is shown as being above the offset voltage (Voff) of the sensor and is produced in response to an external magnetic field.

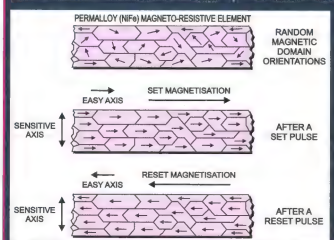


Fig.6: the set and reset pulses applied to the strap coil inside the sensor align the magnetic domains in the resistive element along the easy axis.

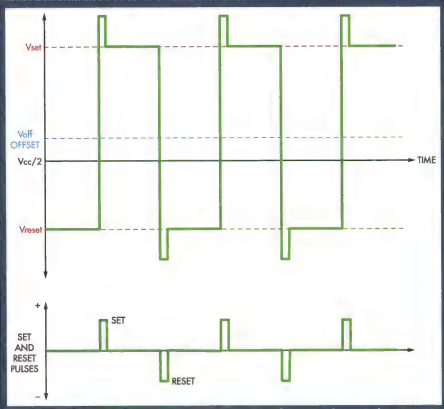


Fig.7: this diagram shows the effect of the set and reset pulses on the sensor's output. Note that the output polarity switches after each pulse.

A reset pulse then follows, after which the output from the sensor goes to Vreset. This again is the voltage difference between Out+ and Out- and is now below Voff.

Note that after a set pulse, a subsequent reset pulse switches the polarity of the sensor's output voltage. Similarly, after a reset pulse, a set pulse switches the output polarity back again.

Fig.7 only applies for one direction of the magnetic field. If the field is reversed, then the polarities of Vset and Vreset are also reversed. In other words, Vset will be lower than Voff after a set pulse, while Vreset will be higher than Voff after a reset pulse.

By contrast, the sensor's offset voltage (Voff) is unaffected by magnetic field variations – it's only the sensor's output that varies. In the absence of a magnetic field, the offset Voff would simply be the difference between Out+ and Out-. In practice though, the device operates in the presence of the Earth's magnetic field.

In summary, we need the set and reset pulses to realign the magnetic domains in the sensor to ensure maximum sensitivity. As a bonus, this also provides a means to calculate the sensor's offset voltage (Voff) and thus compensate for it. That's done by simply adding the Vset and Vreset values together and dividing by two. Calculating Voff at regular intervals then allows us to compensate for offset changes with temperature.

Why compensate for offset?

But why do we need to compensate for the sensor offset? The reason is that changes in the sensor's output in response to magnetic field variations are quite small and so we need to amplify its output. Assuming a 5V supply (as in this circuit), the output varies by around 2.5mV, depending on the sensor's orientation within the Earth's magnetic field (approximately 50μTesla or 0.5 Gauss).

By contrast, the sensor's offset could be up to 11.25mV. So if a 2.5mV signal is amplified by say 500 to obtain a 1.25V signal, the 11.25mV offset voltage would also be amplified by 500 to a level of 5.6V.

That means that unless we compensate for the sensor's offset voltage, the amplified signal could result in the amplifier's output being pegged at either the positive or 0V supply rail, with no resulting change in level due to magnetic field variations.

workings of the magneto-resistive sensor in the panel at left).

As shown on Fig.4, Q2's source is connected to the +5.5V supply rail via a 220Ω isolating resistor and decoupled using a 470μF low-ESR capacitor and a 1μF MKT capacitor. The set pulse current is applied to the strap via the 1μF capacitor as it charges when Q2 turns on, while the discharge current from this 1μF capacitor provides the reset pulse when Q1 turns on.

Both the charge and discharge peak currents are in excess of the 500mA minimum required for this operation.

The accompanying oscilloscope traces (Fig.8 & Fig.9) show the set and reset pulses. In each case, the top trace is the drain voltage of Q2 & Q1, while the lower trace is the pulse applied to the set/reset strap of the sensor. Note that the set pulse is a positive voltage while the reset pulse is negative.

Note also that there is a small amount of "dead time" between when Q2 is switched off and Q1 is switched on. This ensures that they aren't both on at the same time (however briefly) which is necessary to prevent a momentary short across the decoupled supply rail.

In operation, RB0 & RB1 of IC2 drive the Mosfet gates every 10s and both the set and reset pulses decay away over time. These pulses produce a magnetic field in the sensor, so the amplified sensor signal from IC1 is checked by IC2 only while both Q1 & Q2 are switched off to ensure that only variations in the Earth's magnetic fields are detected.

Detection & link options

As previously mentioned, the voltage fed by IC1 to AN2 of IC2 is compared against high and low threshold voltages that track AN2's voltage at a slow rate. Whenever AN2's voltage varies, the thresholds are adjusted up or down by 4.8mV every 1.5s. However, a moving vehicle will cause AN2's signal voltage to vary by considerably more than 4.8mV in much less than 1.5s and so the thresholds will be exceeded.

IC2 detects whenever AN2 goes below the lower threshold or above the upper threshold and drives a bi-colour red/green LED (LED1). The green LED lights for five seconds if AN2's voltage initially goes below the lower threshold, while the red LED lights for 5s if it goes above the upper threshold.

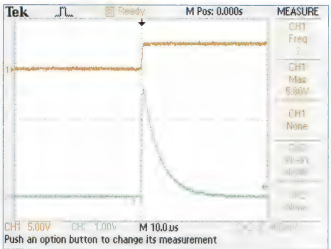


Fig.8: this scope grab shows how the set pulse for the strap coil is generated. Each time IC2's RB0 output briefly goes high, Mosfet Q2 switches on and the commoned Mosfet drains go high as shown by the orange trace. The bottom green trace shows the resulting positive-going set pulse that's then applied to the strap coil via the 1µF capacitor.

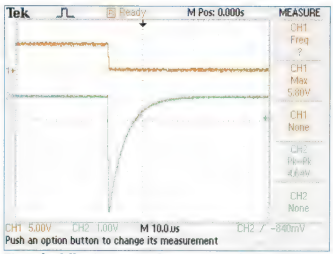


Fig.9: the following reset pulse is generated when RB1 subsequently briefly goes high. This turns on Mosfet Q1 and the commoned Mosfet drains are then pulled to 0V as shown by the orange trace. A negative-going reset pulse (green trace) is then generated as the 1µF capacitor discharges

During this time, the detection process is disabled.

At the same time, a vehicle detection signal is sent to the receiver circuit by the 433MHz transmitter (TX) module, depending on the linking options selected for LK1, LK2 & LK3.

LK1 is used if you want entry (arrival) notifications to be transmitted, while LK2 is installed if you want exits (departures) to be transmitted. Either LK1 or LK2 can be installed, or both can be installed to warn of both arrivals and departures.

LK3 is the "swap" link and is used to set the unit so that it correctly identifies the vehicle's direction (entry or exit). As stated, this direction indication initially depends on the orientation of the driveway and which side of the driveway the detector unit is mounted on. If the directions are incorrect, it's just a matter of installing the link.

Installing LK3 simply swaps over the exit and entry transmission codes that are sent to the receiver and the detection LED colour.

Non-directional signalling

Yet another link option (not shown on Fig.4) forces the Driveway Sentry to send a non-directional signal to the receiver unit, instead of separate entry and exit signals. That's done by installing a link between LK1 & LK2 to short pins 12 & 13 of IC2. The receiver unit then simply indicates that a vehicle has passed by the detector without indicating its direction.

Yet another option is to install a link between LK2 & LK3 to short pins 11 & 12 of IC2. This is a diagnostic connection and we'll describe this in greater detail next month.

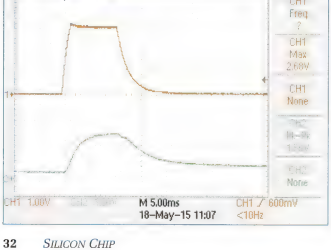


Fig.10: the top trace in this scope grab shows the reference voltage applied to pin 5 of IC1, while the bottom trace shows the filtered output from pin 6 that's fed to the IC2's AN2 input. The reference voltage is about 180mV above the half supply of 2.5V to compensate for the sensor's offset.

IC2 determines which links have been installed by first pulling its RB5, RB6 & RB7 inputs high (ie, to +5V). Its RB4 output is then pulled low (0V) and the RB5-RB7 inputs checked to see if any of these are also now low. If so, then a jumper link must be installed on that particular input.

Determining if there is a connection between RB7 & RB6 or between RB6 & RB5 is only slightly more complicated. It's done by first making RB6 an output and RB4 an input. RB6 is then taken both low (0V) and high (5V) and RB7 & RB4 checked to see if either one follows RB6. If an input follows, then there is a jumper link between it and RB6.

433MHz UHF transmitter

TX1 is the 433MHz transmitter module. Its supply line is switched by Q4 and this transistor is turned on by IC2's RA3 output whenever transmission is required (ie, Q4 turns on when RA3 goes low).

Trimpot VR3 is also connected to the +5V supply rail when Q4 turns on. Its wiper is monitored via IC2's AN0 input and the set voltage is included in the UHF transmission as identity information. This voltage then needs to match the voltage set on a similar trimpot in the receiver unit in order for the transmission to be accepted (ie, in order for pairing to take place).

There are eight valid voltage ranges that can be set using VR3 to select one of eight different identities. As a result, up to eight different detector and re-

ceiver pairs can operate independently in close proximity.

Conserving the battery

As already noted, Sensor1 draws about 5mA and the AD623 amplifier (IC1) about 300µA from the 5V supply when connected via Q3. That's a total of 5.3mA from the 5.5V output of REG1 and means that around 25mA would be drawn from the single 1.25V AA cell that powers everything (taking into account power conversion and efficiency).

Because of this, a number of steps have been taken to minimise the power consumption. First (and as previously mentioned), Sensor1 and IC1 are only powered up each time a measurement is required and that's done for only about 20ms at 300ms intervals. This 20ms duration was chosen to give sufficient time for the filters at IC1's reference (REF) input and at its output to settle (ie, much longer than the low-pass filter time constants of 2.2ms).

As a result, the power on/off ratio is 1/15 and so the average current drawn from the 5V supply is just 5.3mA x 1/15th = 353µA.

The 433MHz UHF module draws 10mA when powered, while VR3 draws a further 500µA. However, they draw very little power overall, since they are only powered up when a UHF transmission is required (ie, when a vehicle is detected).

Even if a vehicle stops next to the detector, the unit will quickly stop transmitting as the upper and lower thresholds catch up to the voltage on IC2's AN2 pin.

Further power is saved by shutting down microcontroller IC2 so that it is in sleep mode for most of the time and drawing a maximum current of just 11µA. This current is much lower than when actually running its internal program and drawing up to 2.8mA.

In operation, IC2 is woken up for 20ms every 300ms by a watchdog timer that runs while it is in sleep mode (ie, 2.8mA is drawn for just 20ms every 300ms). This means that IC2's average current is just 187µA.

An additional power saving has been made by having IC2's RB4 output normally set high, so any jumper links that are inserted do not cause the internal pull-up current to flow. This can save up to 1.2mA if all the links are in place. In operation, RB4 is taken momentarily low when the link connections need to be checked but again the overall average current is quite small.

Parts List: Detector Unit

Detector Unit

1 PCB, code 15105151, 104 x 78mm
1 IP65 polycarbonate enclosure, 115 x 90 x 55mm
1 single AA cell solar panel & wiring
1 AA cell holder
1 NiMH AA cell
1 powdered-iron toroidal core, 15 x 8 x 6.5mm (Jaycar LO-1242)
1 2-way PCB-mount screw terminal with 5.08mm spacing
1 UHF transmitter (TX1) (eg, Jaycar ZW-3100)
1 3-way DIL pin header strip (2.54mm spacing)
3 pin header shunts
1 18-pin DIL IC socket
3 8-pin DIL IC sockets (optional)
1 cable gland for 3-6.5mm cable
7 PC stakes
2 No.4 x 6mm self-tapping screws
4 M3 x 6mm screws
2 5mm ferrite beads
2 100mm cable ties
1 50mm length of tinned copper wire
1 750mm length of 0.5mm-diameter enamelled copper wire
1 170mm length of light duty hook-up wire
1 500Ω miniature horizontal-mount trimpot (code 501) (VR1)
1 1MΩ miniature horizontal-mount trimpot (code 105) (VR2)
1 10kΩ miniature horizontal-mount trimpot (code 103) (VR3)

Semiconductors

1 Honeywell HMC1021S one-axis magneto-resistive sensor (Sensor1)
1 AD723AN instrumentation amplifier (IC1)
1 PIC16F88-I/P microcontroller programmed with 1510515A.hex (IC2)
1 LMC6041IN CMOS micropower op amp (IC3)
1 TL499A power supply controller (REG1)
1 LM2936Z-5.0 low dropout 5V regulator (REG2)
1 IRF540 N-channel Mosfet (Q1)
1 IRF9540 P-channel Mosfet (Q2)
2 BC327 PNP transistors (Q3,Q4)
2 1N4004 1A 400V diodes (D1,D2)
1 bi-colour LED (two lead) LED1

Capacitors

2 470µF 10V low-ESR electrolytic
1 220µF 10V low-ESR electrolytic
1 10µF 16V PC electrolytic
1 1µF 16V PC electrolytic
3 1µF MKT polyester
3 100nF MKT polyester
2 100nF ceramic
1 1nF MKT polyester
2 1nF ceramic

Resistors (0.25W, 1%)

1 100kΩ	2 2.2kΩ
1 22kΩ	1 330Ω
2 10kΩ	1 220Ω
1 4.7kΩ	2 10Ω

Power supply circuit

The single 1.25V AA cell's output is stepped up to 5.5V using step-up regulator REG1. Regulator REG2 is then used to derive the 5V rail.

This second regulator helps remove any switching noise from the output of the step-up regulator and provides a well-regulated 5V supply to power Sensor1, IC1, IC2 and the 433Hz TX module.

In greater detail, REG1 is a TL499A step-up regulator. In operation, current flows through inductor L1 each time REG1's SW IN output (pin 6) switches low. When this reaches a peak value, the SW IN output is switched off and the stored energy in the inductor is fed via an internal diode to the pin 8 output. This output is then filtered using a 100nF MKT capacitor and a 220µF low-ESR capacitor.

The 330Ω resistor between pin 4 of REG1 and ground sets the peak current through the inductor to about 300mA. Voltage regulation is achieved by sampling the output voltage using a resistive divider (VR2 and 100kΩ) and then feeding this sampled voltage to the reference input at pin 2. In this case, the inductor switching rate must be adjusted so that pin 2 is kept at 1.26V.

This means that for a 5.5V output, the voltage divider needs to reduce the 5.5V down to 1.26V and that's done

Parts List: Receiver Unit

1 PCB, code 15105152, 79 x 47mm
1 433MHz UHF receiver (RX1) (Jaycar ZW-3102)
1 12V DC plugpack rated at 100mA
1 UB5 or UB3 case (see Pt.2)
1 8-pin DIL IC socket
1 PCB mount DC socket with 2.1 or 2.5mm centre pin to suit plugpack plug (CON1)
6 PC stakes
1 170mm length of light-duty hook-up wire
1 20mm length of 1mm-diameter heatshrink tubing
2 10kΩ miniature horizontal mount trimpots (code 103) (VR1,VR2)

Semiconductors

1 PIC12F675/I-P microcontroller (programmed with 1510515B.hex (IC1)
1 78L05 5V regulator (REG1)
1 1N4004 1A diode (D3)

Capacitors

2 100µF 16V PC electrolytic
1 100nF MKT polyester

Resistors (0.25W, 1%)

1 1kΩ 1 100Ω

Extra Parts For Version 1 (Relays & Mains Remote Control)

1 UHF remote controlled mains switch (Altronics A 0340, Jaycar MS-6145, MS-6142)
1 UB3 box 130 x 68 x 44mm
2 SPST DIP 5V reed relays (Altronics S4100A, Jaycar SY-4030) (Relay1,Relay2)
2 1N4148 diodes (D1,D2)
3 2-way pin headers
3 2-way pin header plugs
1 100Ω 0.25W 1% resistor
2 M3 x 9mm tapped spacers
4 M3 x 6mm tapped spacers
12 M3 x 6mm screws OR
6 M3 x 6mm screws AND
6 M3 x 6mm countersunk screws
120mm x 6-way rainbow/IDC cable

Extra Parts For Version 2 (Audible & Visual Indication)

1 UB5 box, 83 x 54 x 31mm
2 M3 x 9mm tapped spacers
4 M3 x 6mm screws
1 piezo transducer (Jaycar AB-3440, Altronics S 6140)
1 green high intensity LED (LED1)
1 red high intensity LED (LED2)
1 1kΩ 0.25W 1% resistor

with VR1 set to 336kΩ.

The voltage from the divider is then buffered using op amp IC3 (which is configured as a voltage follower) before being fed to pin 2 of REG1. This buffer stage allows the use of higher-value divider resistors than would otherwise be the case and this was again done to minimise power consumption.

REG1's 5.5V output appears at pin 8 and is used to drive regulator REG2. The 5.5V rail from REG1 is also as the supply for the set/reset pulse generator circuit based on Mosfets Q2 & Q1.

REG2 is a low quiescent current and low drop-out regulator. Its low drop-out specification means we only need to provide 5.5V for the regulator to fully regulate to 5V. By contrast, most standard regulators require at least a 6.5V input to regulate to 5V.

Average current

The average current drawn from the 5V supply is around 550µA. However, the current drawn from the AA cell is much higher than this. That's because the AA cell has an output of just 1.25V and this is stepped up to 5.5V before being regulated to 5V. So you would expect the current drawn from the AA cell to be some 5.5/1.25 = 4.4 times higher, assuming that the TL499A regulator's step-up efficiency is 100% which, of course, it isn't.

At a more realistic 70% efficiency, the current would be expected to be 6.3 times higher. And that means that the calculated total average current drawn from the AA cell is 3.5mA.

In practice, we measured a current drain of close to 3mA in our prototype. That means that a 2000mAh AA NiMH cell would last for about 28 days without recharging. The solar panel we tested charged the cell at 20mA in mid-morning autumn sunlight and that is more than sufficient to maintain the cell's charge.

Diode D1 provides protection if the solar panel is connected with the wrong polarity, while D2 provide reverse polarity protection if the 1.25V cell is inserted in its holder the wrong way around.

Finally, resistor R1 is included to provide current limiting if a 9V or 12V mains plugpack is used instead of a solar panel to recharge the battery. This resistor is normally shorted out on the PCB since it is not required when a solar panel is used. However, the PCB track has a section that's easily cut if the resistor is required (see the construction details next month).

Receiver circuit

Fig.11 shows the receiver circuit details. It's based on the 433MHz receiver module, an 8-pin PIC12F675 microcontroller (IC1) and a 5V regulator (REG1). Also shown are the entry and exit LEDs, the piezo transducer and the alternative reed relays.

Microcontroller (IC1) monitors the data signal output from the UHF RX (receiver) module and acts when it receives a valid code. The arrival, departure and non-directional signal codes are all different, so that IC1 can discriminate between them.

IC1 also monitors trimpot VR1 at its GP4 input. This is the identity adjustment that is divided up into eight separate voltage bands. This voltage needs to match that set in the detector unit before any received signal is deemed valid.

Trimpot VR2 has its wiper monitored by IC1's GP2 input (pin 5). This trimpot sets the alert duration. Alternatively, it sets the time period between relay 1 closing and relay 2 closing (and thus the period for which a remote-controlled mains socket is powered on).

In operation, IC1 converts the voltages at GP4 and GP2 to 8-bit digital values. When a valid signal is received, its GP0 and GP1 outputs drive either the piezo transducer and one of the LEDs (LED1 or LED2) or relays Relay1 and Relay2. If used, the latter are wired across the On and Off switch contacts on the hand-held remote that's used with a remote-controlled mains socket.

Piezo transducer

The exit (or departure) tone from the piezo transducer is a 440Hz horn-type "bip" lasting about 1s, followed by a 440Hz tone that smoothly increases to 6.8kHz over a period ranging from 1-5s (depending on the setting of VR2). LED1 (exit) also lights while ever the piezo sounds and stays lit for about 15s after the tone ceases.

By contrast, the entry (or arrival) tone starts with a 1s 440Hz horn "bip" and is followed by a 6.8kHz tone that decreases to 440Hz (again adjustable

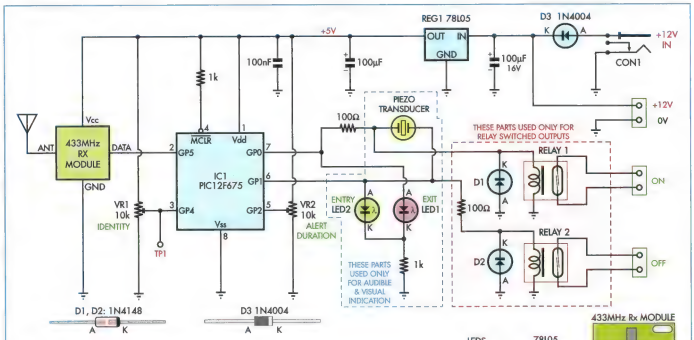


Fig.11: the circuit diagram for the receiver circuit. The 433MHz RX (receiver) module picks up the signal from the detector unit and feeds its data output to PIC microcontroller IC1. When a valid code is received, IC1 drives a piezo transducer & activates either LED1 or LED2 to indicate vehicle entry or exit. Alternatively, the LEDs & piezo transducer can be omitted and reed relays fitted instead. These can then be wired across the buttons of a remote control unit, eg, for a remote-controlled mains socket or a wireless doorbell.

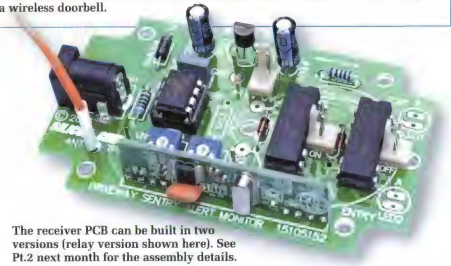
from 1-5s). This makes it quite distinct from the exit sound, since the tone now decreases instead of increasing. In addition, the entry LED (LED2) lights during the tone and again stays lit for 15s after the tone ceases.

The non-directional tone is different yet again. In this case, there is a 1s 440Hz horn "bip" followed by a further 440Hz "bip" lasting from 1-5s. In addition, LED1 & LED2 both light and then flash alternately for 15s after the tone ceases.

Relay version

For the relay version, Relay1 is first switched on for 500ms, thereby allowing its closed contacts to activate the "On" button on a UHF remote control (eg, for a mains socket). Then, after a preset period ranging from 20s to five minutes as set by VR2, Relay2 is switched on for 500ms to activate the "Off" button on the UHF remote.

Both relays are driven via 100Ω resistors, while diodes D1 & D2 clamp any switch-off voltage spikes produced by the relay coils. The 100Ω resistors are there to protect IC1's GP0 & GP1 outputs.



The receiver PCB can be built in two versions (relay version shown here). See Pt.2 next month for the assembly details.

The program in IC1 automatically detects if the piezo transducer has been installed or if the relays have been installed instead. It does this by first making the GP1 pin an input and then switching GP0 high. If GP1 goes high immediately after switching GP0 high, then the piezo transducer is connected. That's because the piezo transducer's capacitance allows the voltage transition to be coupled through to GP1.

Conversely, if GP1 stays low, the software assumes that the relays are connected since Relay2's coil provides a low resistance path to ground.

Power for the circuit is derived from a 12V DC plugpack, with diode D1 providing reverse polarity protection. REG1 then provides a regulated 5V supply for IC1 and the UHF RX module. The 100µF input and output bypass capacitors provide supply line filtering, while a 100nF capacitor provides additional decoupling for the supply going to the microcontroller.

That's all for this month. Pt.2 next month has the assembly details. SC

By NICHOLAS VINEN

Fitting USB charging points to the car's courtesy/reading lamp assembly makes it easy to power USB accessories such as dashcams, GPS satnav units and smartphones.

Install USB charging points in your car

New cars often have more than one USB socket for charging phones etc but older cars have none. This tiny PCB will let you add one or two USB sockets and the total charge current can be up to 2.5A, more than enough for phones, satnavs or dash cameras.

EVEN IF YOUR CAR has a USB socket, it probably is not in the ideal spot. Many people want to use a dash camera or a GPS satnav and in each case this means an untidy USB cord dangling over the dash to the closest 12V accessory socket. Ideally though, you need a USB socket close to the accessory you are using, either somewhere on the instrument panel or close to the rear vision mirror, possibly built into the housing for the sunglasses holder.

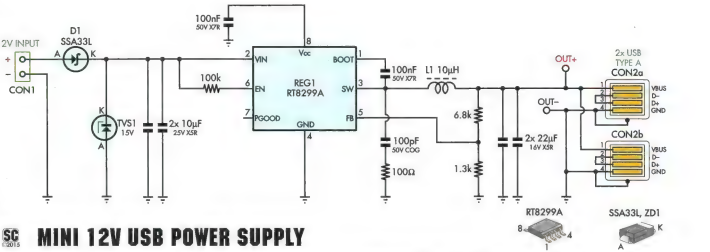
Another point is that people want a USB socket in their car which is powered all the time, even when the car is locked up at night. This would allow you to charge a phone at any time – very handy if your area has no power for days at a time or you are on a camping trip.

So that is the main reason for this little project. It lets you tap into the car's 12V courtesy light bus because that is always powered, ready to turn on the interior lamps whenever you open a door.

The tiny PCB is small enough to be tucked up inside a typical reading lamp assembly located just behind the rear vision mirror. One or two USB sockets can then be fitted in cutouts made in this assembly, so that the accessories can be plugged in using standard USB cables.

But that's just the start of what this tiny PCB can be used for. There are many situations where you may want to efficiently derive 5V or 3.3V from a higher voltage at an amp or two.

It uses just a handful of parts costing only a few dollars and a tiny (and



SC MINI 12V USB POWER SUPPLY

Fig.1: the circuit is based on an RT8299A switchmode step-down regulator (REG1). TVS1 protects the regulator from transient voltage spikes, while diode D1 provides reverse polarity protection. REG1 feeds two type-A USB sockets.

thus cheap) PCB. The parts are almost all SMDs but most are easy to solder and you could probably build it in under an hour.

Circuit description

The circuit diagram is shown in Fig.1. It's based on an RT8299A switchmode regulator IC from Richtek, a Taiwanese-based semiconductor manufacturer founded in 1998. They have released many low-cost, high-performance integrated switchmode regulator ICs and this is one of them – the data sheet is dated January 2014.

The RT8299A is a 500kHz synchronous step-down regulator. It incorporates an oscillator, ramp generator, voltage reference, under-voltage lockout circuit, error amplifier, compensation components, comparator, flipflop, Mosfet drivers, Mosfets and a current sense shunt/amplifier. Fig.2 shows its internal block diagram, taken from the data sheet.

Before we get into the details of its operation, let's have a quick look at how a "buck" or step-down switching regulator works. Fig.3 shows the general concept.

Switch S1 is rapidly toggled and while we're showing it as a mechanical switch it will normally be a Mosfet. While S1 is closed, current flows from the V_{IN} + terminal, through S1, inductor L1 and into the load, while simultaneously charging up output filter capacitor C1.

Note that when S1 initially closes, very little current flows as inductor L1 initially presents a high impedance. The current then ramps up in a linear fashion and builds up L1's magnetic field.

When S1 opens, L1's magnetic field begins to collapse and the presence of the field means that current continues to flow into the load. This current must therefore come from ground, via diode D2 (labelled PATH 2). The current through L1 falls linearly as its magnetic field discharges and similarly, the voltage across C1 drops as this capacitor helps to supply some of the load current.

S1 then closes again and the process repeats. The end result is that, depend-

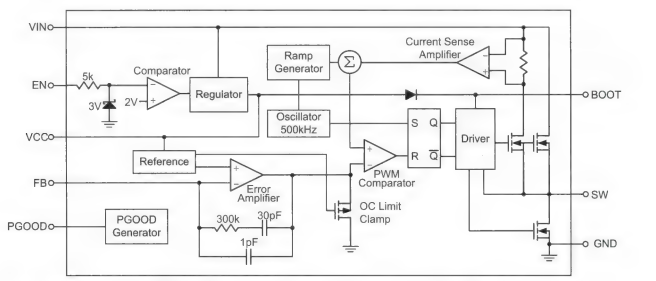


Fig.2: block diagram of the RT8299A switchmode regulator. It incorporates an oscillator, a ramp generator, voltage reference, under-voltage lockout circuit, error amplifier, comparator, flipflop, Mosfet drivers, various Mosfets and a current sense shunt/amplifier

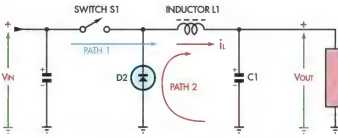


Fig.3: basic scheme for a switchmode buck converter. Voltage regulation is achieved by rapidly switching S1 and varying its duty cycle. The current flows via path 1 when S1 is closed and path 2 when it is open. In a practical circuit, S1 is replaced by a switching transistor or a Mosfet.

ing on the switching duty cycle (ie, the proportion of the time that S1 is on), the voltage at V_{OUT} is proportionally lower than that of V_{IN} but depending on efficiency, the power drawn from V_{IN} is similar to that delivered to V_{OUT}, despite the different voltages. Thus a switchmode regulator is usually much more efficient than a linear regulator.

Synchronous regulation

Of course, no circuit is 100% efficient so the output power will be less than the input power. Ideally, we want to minimise this power loss. There are several sources of inefficiency in a buck regulator circuit. One is the DC resistance of the inductor, which typically consists of many turns of wire and like any other resistor, energy is lost as current flows through it. Similarly, at the sort of switching frequencies typically used to keep the output ripple voltage manageable, there can be some core loss in the inductor too.

Another major source of inefficiency is the forward voltage of diode D2. Since D2 conducts more of the time at lower duty cycles, which are required when the output voltage is much lower than the input voltage, this loss can be quite significant under typical conditions. Usually a Schottky diode is used as these have a lower forward voltage however the loss due to D2 can still be significant.

The RT8299A IC addresses both of these major inefficiencies. First, its relatively high 500kHz switching frequency means that only a low value is required for L1. In fact, the recommended value is just 2.2µH. This means fewer turns of wire, so the wire can be both thicker and shorter and thus the resistive losses are low.

Then there is the fact that it is a "synchronous" regulator. This means that diode D2 is replaced with a second switching element (let's call it S2) and this is driven synchronously with S1, ie, when S1 turns off, S2 immediately switches on. In the case of the RT8299A, S2 is another internal Mosfet.

The advantage is that rather than the fixed voltage loss of a diode at high current (eg, 1V for a standard PN silicon diode or 0.5V for a Schottky diode), there is only the typical I^2R Mosfet loss. The RT8299A's internal Mosfets have a typical on-resistance of 0.1Ω so at 2.5A, the voltage loss is similar to that of a 3A Schottky diode (ie, around 0.5V).

Most importantly, when the output current is lower, the I^2R loss is significantly less. For example, when it's delivering 1A, the I^2R loss will be well under 0.1V (as the duty cycle of S2 is less than 100%). The internal low-side switch also means one less external component is required and PCB space is saved.

The result of all this is that the efficiency is very good, up to 95% – see Fig.6. This means that even if you're drawing the maximum specified current from the board, it will barely even get warm. Which is good if you're going to tuck it away into a small space.

Back to the circuit

Now refer again to the full circuit of Fig.1. The operation of REG1 with respect to L1 was described above. Two paralleled 22µF SMD multi-layer ceramic capacitors are used as the output filter; this combination has very low ESR (equivalent series resistance), keeping the output ripple voltage very low. Similarly, two 10µF ceramic capacitors are paralleled for input bypassing, to ensure that REG1 has a stable supply voltage.

The 100pF capacitor and 100Ω resistor in series are a snubber from the switch node (pin 3 of REG1) to ground. This reduces the voltage slew rate at this pin when REG1's internal Mosfets

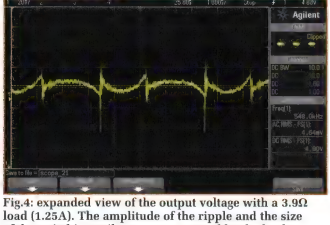


Fig.4: expanded view of the output voltage with a 3.9Ω load (1.25A). The amplitude of the ripple and the size of the switching spikes are exaggerated by the lead inductance of the scope probe. As you can see, the output is close to 5V (4.9V) and the ripple voltage is very low at less than 5mV RMS with a frequency of 548kHz.

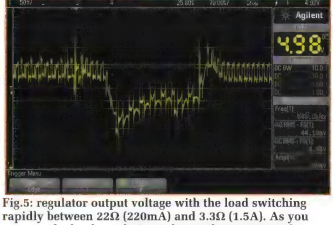


Fig.5: regulator output voltage with the load switching rapidly between 22Ω (220mA) and 3.3Ω (1.5A). As you can see, the load regulation is better than 75mV and recovery is quick (timebase is 10µs/div). Note that the regulator is operating in discontinuous mode before the load step.

Features & Specifications

Wide input voltage range: 4-16V

High efficiency: typically >90%, 0.5-2A

Output voltage range: 0.8-15V (must be at least 2V below input)

Output current: up to 2.5A

Quiescent current: approximately 1mA

Output ripple and noise: typically <5mV RMS @ 1.2A (see Fig.4)

Load regulation: ~150mV/A, 0-250mA; ~75mV/A, 250-2500mA

Line regulation: <1mV/V

Transient response: output stabilises within ~20µs for a ±1.2A load step (see Fig.5)

Other features: no heatsinking necessary, soft start, short circuit protection, over-current protection, overheating protection, under-voltage lockout

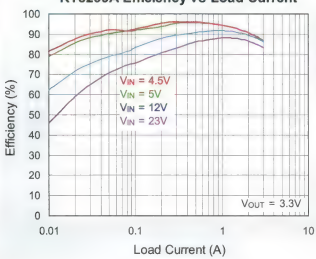


Fig.6: the efficiency of the circuit is very good – up to 95% and above 85% for input voltages up to 12V and load currents greater than 150mA.

are being switched, reducing emitted radiation (ie, EMI).

A transient voltage suppressor (TVS1) protects REG1 from brief high-voltage spikes which may occur on a vehicle 12V bus due to load dumps and so on. REG1 can withstand around 26V (normal operating maximum 24V) so TVS1 was chosen as it will clamp REG1's supply to below 24V even if it has to dissipate up to 400W for around 10ms (ie, 16A). Its leakage current at normal automotive supply voltages (12-15V) is minimal.

D1 provides reverse polarity protection, should the board be wired backwards. It's a 3A Schottky diode so will have only a small effect on efficiency, with a forward voltage of less than 0.5V under typical conditions.

There are two 100nF capacitors connected to REG1. One is from the switch node (pin 3) to one labelled "BOOT" (pin 1). This is charged up to 5V when pin 3 is low by REG1's internal diode and then shoots up to V_{IN} + 5V when the SW pin goes high. REG1 uses this as a gate drive voltage source for its internal upper Mosfet.

The other 100nF capacitor, at pin 8 (V_{CC}), is used to filter REG1's internal 5V rail which is used for various purposes. It's derived from V_{IN} within REG1 via linear regulator circuitry.

Feedback

The feedback voltage to pin 5 of REG1 comes from a simple resistive divider comprising 6.8kΩ and 1.3kΩ resistors across the output. REG1 attempts to maintain this feedback voltage at 0.8V and since the division ratio is 6.8kΩ ÷ 1.3kΩ + 1 = 6.23, this gives an output voltage of 0.8V x 6.23 = 4.985V.

In practice, due to various component tolerances, it will be in the range of 4.9-5.1V.

If you want a different output voltage, change the 6.8kΩ resistor. You

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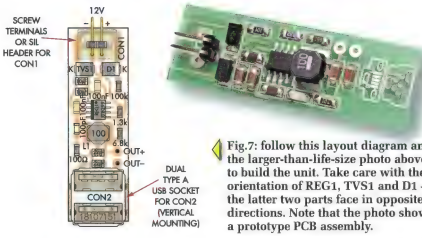


Fig.7: follow this layout diagram and the larger-than-life-size photo above to build the unit. Take care with the orientation of REG1, TVS1 and D1 – the latter two parts face in opposite directions. Note that the photo shows a prototype PCB assembly.

calculate the new value in kilohms as: (V_{OUT} x 1.625) - 1.3 and pick the nearest value. For example, 3.9kΩ will give an output close to 3.3V (actually 3.2V). In this case, USB connector(s) would not be fitted and the board would drive some other circuitry.

The 100kΩ resistor from pin 6 (EN) to pin 2 (V_{IN}) causes the regulator to switch on as soon as power is applied.

Output connectors

As shown in the circuit, two USB output connectors can be fitted to the PCB. The board has provision for a dual USB type-A vertical connector to be used. Alternatively, a single vertical type-A connector can be fitted in the same location, or a horizontal type-A connector (they have the same pin spacing). Which one you use depends on the particular way you are going to install the board.

It's also possible to fit off-board connectors via flying leads, which is what we had to do in the Honda Accord we fitted the prototype to, due to limited space in the reading lamp assembly. For other applications, you can simply run a figure-8 lead from the two pads provided on the board. This can be strapped to the blank area at the bottom of the PCB with a cable tie for strain relief.

Normally, for a USB charger, the D+ and D- lines (green and white wires in the cable) are shorted together. This tells the connected device that it's plugged into a charger rather than a computer, so it can immediately draw more than 100mA. With a computer, a device has to negotiate to draw more than this – but in our circuit there's nothing to "talk" to the USB device.

For the power input, you can either fit a small terminal block, a pin header or just wire it up via flying leads. The flying leads will take up the least space, although we used a right-angle pin header to make installation easier.

Construction

The PCB overlay diagram is shown in Fig.7. Note that while we're showing the PCB as a single-sided design (as indeed it is), the boards we supply are double-sided with a full ground plane on the underside. This should help reduce EMI and also slightly improve efficiency.

As stated earlier, most of the components are SMDs. Only the connectors are through-hole parts. REG1 is in an 8-pin SOIC package which has a convenient 1.27mm pin spacing so it's not hard to solder.

Start the assembly of the PCB by fitting REG1. While an SOIC-8 package is generally easy to solder, this one has a thermal pad on the underside which is also supposed to be soldered to the board. To do this properly, you need to use a hot-air rework station. These are available from eBay sellers for around $50 (eg, search for "Atten 858d").

If you have one of these, simply apply some solder paste to each pad, place the IC on top, check its orientation carefully (pin 1 to upper left) and then heat the IC and its leads until the solder reflows. Be sure to continue heating it long enough for the solder on the thermal pad to melt also; you can usually see fumes from the flux escaping under the IC.

While we recommend this method, it is possible to solder the chip by hand. To do this, first place a small amount of non-conductive (silicone-based) heatsink paste on the central pad and clean the residue off the other pads. That done, tin one of the eight remaining pads, carefully place the IC in position and reheat that pad while pressing down gently on the IC until its lead contacts the PCB.

Once it's in place, check the alignment, then solder the remaining seven pins and add some solder to that first pin to refresh the joint. Any solder bridges between pins can then be easily cleaned up using solder wick.

Note that it's best to avoid moving the IC by much during soldering, so that the heatsink paste is not spread around. Also, don't clean the board using any solvents as these are likely to wash the paste away.

One of the most common problems with soldering an IC like this is that it's possible to get solder on a pin without it actually flowing onto the corresponding pad. **As a result, it's best to check all eight leads under a magnifying lamp to make sure the solder fillets are properly formed.**

With REG1 in place, L1 is next. This is a little tricky due to its high thermal inertia. There are various methods but the simplest is to treat it like a large chip component. This involves adding a fair bit of solder to one of the pads, enough that it's visibly built up, then heating this solder while sliding L1 into place along the surface of the PCB. It's easiest to do this while holding it with angled tweezers.

As soon as L1 hits the solder, some of it will cool and solidify. You will have to hold the iron in place while L1 heats up and the solder will then re-melt. Once that happens, you can finish sliding L1 across into the correct position between the two pads. You can then flow solder onto the opposite pad.

Note that it's best to do this immediately before L1 cools down. Note also that it will take a little while to apply enough heat to form a good joint. Make sure a proper glossy solder fillet is formed.

You will then need to go back and add some more solder and heat to the initial pad, until you get a similarly good fillet on that side; much of the flux will have boiled off during the initial soldering process.

The rest of the components are much easier as they are substantially smaller but you can use the same basic idea of adding solder to one pad and then sliding the part into place. The only

remaining polarised components are D1 and ZD1; in each case the cathode (striped) side goes towards the nearest edge of the PCB.

Don't get any of the different value capacitors, resistors or diodes mixed up. The resistors will have printed value codes on the top but the other components are likely to be unmarked so you will have to remove them from their packaging one at a time and immediately solder them into the correct locations.

Fitting CON1 &/or CON2

Finally, fit your choice of CON1 and CON2 in the usual manner. It isn't strictly necessary but if using a horizontal socket for CON2, you may want to place some insulation over the unused set of pads near the edge of the board, to prevent the shell shorting to them. We say this is probably not necessary because those pads should be covered with solder mask on the top side of the board and so there's unlikely to be enough exposed metal for the connector shell to touch.

Note that soldering the retaining posts for CON2 may be a little tricky as there isn't much "meat" on the pads, since they are pretty close to the edge. However, if you apply enough heat and flow a sufficient amount of solder into the mounting holes, it should adhere to the copper plating inside the holes and provide a good mechanical connection.

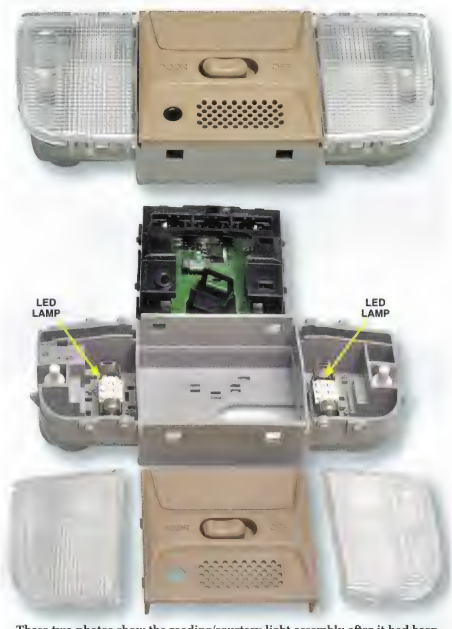
When the PCB is finished, carefully check your work and then connect it to a source of 12V or it could even be initially powered from a 9V battery. Make sure you connect it with the correct polarity, otherwise nothing will work.

Once powered, check that you have 5V (or very close to 5V) at the relevant points on the USB socket (on the back of the PCB). If that checks out OK, you are ready to install it.

Fitting it in your car

Depending on your application, it's up to you how you wire up and secure the assembly. A short length of clear heatshrink tubing is a good way to encapsulate the board if it isn't going to be held rigidly in place. But now we're going to show you how we fitted in into a test car. The details for other cars will be different but the general principles should apply across many common models.

First, most vehicles will have 12V



These two photos show the reading/courtesy light assembly after it had been removed from the car (top) and after it had been stripped down to its major sub-assemblies. The standard incandescent lamps should be changed to 12V LED lamps to reduce the overall power consumption (see text).

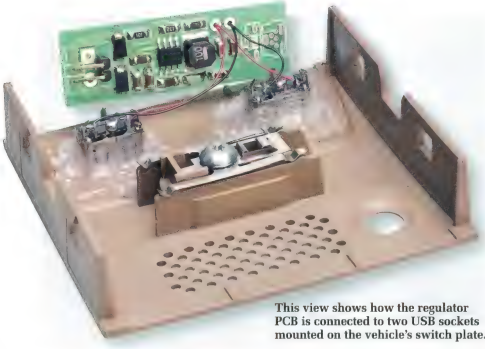
power permanently available in the reading lamp assembly. If you wire the unit up to that power, the USB sockets will be constantly on. Of course, you could add a switch to turn it off when not needed (which may be easier than turning the connected devices on and off each time) but we didn't bother.

While the circuit only draws about 1mA by itself, you will need to switch any GPS navigation units or dash cameras on/off manually as they won't be switched automatically with the ignition, as they are when powered from an accessory socket.

And if you are going to install the PCB inside the reading/courtesy lamp assembly, we strongly suggest that you change the standard incandescent lamps to 12V LED fittings. This is desirable to reduce overall heat production inside the housing and also to reduce the overall current drain from the car's 12V courtesy light bus.

We had an article showing how to do this in the December 2013 issue – see www.siliconchip.com.au/Issue/2013/December/Update+Your+Car's+Interior+With+LED+Lighting

Anyway, the first step to fitting the



This view shows how the regulator PCB is connected to two USB sockets mounted on the vehicle's switch plate.

unit is to remove the light assembly. In our car, we first pushed in each reading lamp lens in turn, then slid a slim flat-bladed screwdriver wrapped in a cotton cloth under the edge and prised the clear plastic cover off (as described in the vehicle manual). This revealed the head of a retaining screw on each side.

Removing the two screws required a large screwdriver and quite a bit of force – they were done up very tightly and we didn't want to strip the heads. The whole lamp assembly then came down from the roof. We simply had to unplug two multi-way cables and the whole thing could be removed.

To remove the brown plastic cover from the centre section, we used the same screwdriver to press in the four plastic tabs at top and bottom. The whole central assembly was then removed and four further clips had to be pressed in to separate this into two further sections, as shown in one of the photos.

The lower black plastic section contains a PCB with a Mosfet to control the light dimming, the switch to control whether the courtesy lamp comes on when the doors are opened, a LED to illuminate the gear shift lever and a few other bits and pieces.

Finding 12V power

Since this module included the Mosfet to control dimming, it seemed likely that there was a permanent source of 12V power connected to the board.

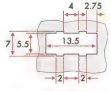


Fig.8: use this diagram as a template for marking out the USB socket cut-outs. Note the notches on either side.

Fig.9: the OUT+ (5V) and OUT- (GND) pads on the PCB are connected to the USB sockets as shown here.

We examined the PCB for likely points where this might be connected (eg, the source tab of the Mosfet), then plugged the board back into the car's electrical system and checked each point for continuity with the vehicle's chassis via the exposed metal where the retaining screws had been.

We got a reading of less than one ohm from one of these tracks to the chassis and made a note of its location as this was a good place to connect the USB power supply ground. We then switched the DMM into voltmeter mode, connected the black probe to chassis and probed other large tracks with the red probe. We quickly found a track which reliably gave us a reading of around 12.5V so we noted this also.

It was then just a matter of scraping back a little of the solder mask on these two tracks and soldering some red and black wires with a 2-way DuPont-style header plug on the other end (see photo on facing page).

Installing USB sockets

The next task was to fit sockets on the blank plastic plate between the two reading lamps. Ideally, we would have used a panel-mount USB socket but there simply wasn't room. These also tend to be fairly expensive compared to normal PCB-mounting USB sockets.

Instead, we decided to press a couple of regular vertical PCB-mounting sockets into service. The idea was to drill a series of holes in the panel, then use files to shape the holes into rectangular slots and secure the sockets in place with silicone sealant.

This approach is workable but there are a few catches you need to be aware of. First, typical USB sockets are designed to mount behind a thin steel or aluminium plate and there are six spring-loaded clips arranged just behind the front of the socket which hold the USB plug in place using friction, so it doesn't fall out. A thicker plastic panel can interfere with these springs and cause the insertion and retention force to be much higher than desirable.

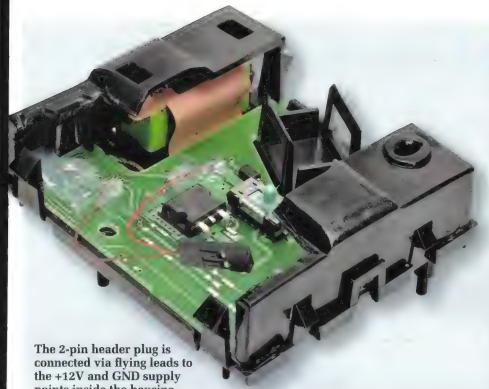
Similarly, you have to be careful when gluing the socket in to avoid glue getting inside the socket (as they typically aren't sealed) and also to avoid gluing the springs in place! If you do this it will be virtually impossible to insert a USB plug and if you do somehow manage to do it, good luck getting it out!

Ultimately, we came up with the following approach. First, we profiled the holes to leave a little extra clearance in the places where the springs sat to allow them to move. We then secured the socket in place using silicone sealant which, while very strong, is flexible enough to allow the springs to move in order to keep the insertion and retention forces to a more-or-less normal level.

Cutting the holes

First, decide where the sockets are to be fitted and keep in mind that there needs to be enough room behind the panel for them to project into, without the risk of shorting to anything conductive. Also, you need to leave enough room for the DC/DC converter PCB to fit.

In our case, the logical place to mount the sockets was evidently in-



The 2-pin header plug is connected via flying leads to the +12V and GND supply points inside the housing.

tended to house three extra illuminated buttons or lamps which were not fitted to this vehicle. As a result, we had to cut away the plastic that would have held these devices in place to make room for the sockets. As luck would have it, this also left enough room to fit the regulator board just behind the sockets. You can see the modifications made to the black plastic frame in the accompanying photograph.

We then marked out the socket locations on the brown plastic fascia and drilled three 5mm holes space slightly apart in each location. We then slowly filed these into a rectangular shape until the sockets fitted through and were held in place by friction – but only just. If the sockets fit too tightly, this will make it difficult to plug the cable in.

We then used a small round file to make four small notches in each cut-out, corresponding to the two pairs of spring clips on the top and bottom surfaces of the sockets. This gives the clips some room to expand when a plug is inserted. The notches are 6mm apart and only about half a millimetre deep – see Fig.8. Any deeper than this and they won't be covered by the flange surround on the front face of the socket.

We then pushed each socket into its corresponding hole and checked that it was possible to insert and remove a USB plug with a reasonable amount of force. You will need to get a good hold onto the rear of the socket to test unplugging. We then applied silicone sealant around all the edges of the socket where it met the plastic panel and left it for 24 hours to set.

Try to avoid pushing too much sealant into the spring clip holes and definitely avoid getting any on the solder tabs, especially since there is usually a large hole in the back of the socket. If you do get some silicone inside the front of the connector (ie, near the entry side), you can remove it carefully using the tip of a sharp hobby knife.

Wiring it up

Now for the final connections. As stated earlier, we connected a 2-pin header plug to the 12V and GND supply points inside our housing and if you haven't already done something similar, do it now. This then plugs into the 2-pin header on the PCB.

You will then need to solder wires to the rear of the USB sockets – use Fig.9 as a guide. The two central pins can simply be joined with a solder bridge or if you can't get one to form, use a small piece of tinned wire (eg, a component lead off-cut).

The 5V and GND pins of the two sockets are wired up to the outputs on the regulator PCB in parallel. We did this by running a separate pair of wires from each socket to the solder pads on the board but you could run wires between the two sockets if you prefer.

Be very careful to follow the pin-out diagram of Fig.9 and observe the polarity of the output pads on Fig.7.

Parts List

1 PCB, code 18107151, 16 x 51mm
1 4.7-10µH 2.5A RMS (3A saturation) 6x6mm SMD inductor, eg, NR6045T100M (L1) (element14 2289085, Digi-Key 587-2081-1-ND)
1 2-way mini terminal block or pin header (CON1) (optional)
1 dual stacked vertical type-A USB socket, through-hole mounting (CON2) (element14 1841169, Digi-Key ED2984-ND) OR
2 vertical or horizontal type-A USB sockets, through-hole mounting (CON2) (element14 1696534/1654064, Digi-Key UE27AC54100-ND/ UE27AE54100-ND)
1 50mm length of 20mm-dia. heatshrink tubing

Semiconductors

1 RT8299AZSP 3A Switch-mode Step-down regulator IC (REG1) (element14 2392669, Digi-Key 1028-1295-1-ND)
1 3A 30V Schottky diode, DO-214AC (D1) (element14 1843685, Digi-Key SK33A-TPCT-ND)
1 SMAJ15A SMD 15V 400W TVS or equivalent (TVS1) (element14 1886343, Digi-Key SMAJ15ALFCT-ND)

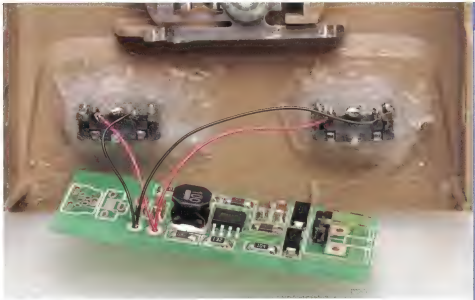
Capacitors

2 22µF 16V X5R/X7R SMD 3216/1206*
2 10µF 25V X5R/X7R SMD 3216/1206*
2 100nF 50V X7R SMD 3216/1206*
1 100pF 50V C0G/NP0 SMD 3216/1206*

Resistors (SMD 3216/1206*, 1%, 0.25W)

1 100kΩ 1 1.3kΩ
1 6.8kΩ 1 100Ω

* 2012/0805-size parts are also suitable



The two USB sockets can be secured to the switch plate cover using neutral-cure silicone adhesive and wired as shown here. Note that two centre pins on each socket are shorted together with solder.

You can measure how much current your USB devices are drawing using this Power Monitor – see text.

Most USB devices won't have reverse polarity protection and will probably be damaged if the sockets are wired up incorrectly!

Once you've done that, you can slip a piece of heatshrink tubing over the DC/DC converter board and plug the 2-pin header in (be careful with polarity – see Fig.7) before shrinking the tubing down.

It's then simply a matter of reassembling the whole thing while tucking the regulator board away inside it. Plug the connectors back into the vehicle's wiring harness and secure the lamp assembly in place in the vehicle. You can then plug a USB device with some sort of power indicator in to test it. We suggest something cheap! We used a card reader to verify that the USB power supply was working correctly on both sockets before plugging in our GPS unit and dashcam.

Quiescent current/power draw

The DC/DC converter board only draws around 1mA so, by itself, it will add only a negligible load to the battery, even when wired in permanently. However, be aware that anything you leave plugged into the sockets could draw significantly more than this and may flatten the vehicle battery if it isn't driven for long periods. This could be true even if the device(s) plugged in are switched "off" – they may still be drawing current to keep their batteries topped up etc.

The only way to know for sure is to measure it. You could use our USB Power Monitor, which was described in the December 2012 issue – see www.siliconchip.com.au/Issue/2012/December/USB+Power+Monitor A complete kit is available from Jaycar, Cat. KC5516.

This will allow you to measure how much current is drawn from the USB socket by any given device in various modes, including standby/off. Divide this current in two to get an idea of how much extra load it places on the vehicle's battery.

Let's say, for example, that you have a GPS and a dashcam plugged in and you've measured their total current drain when switched off at 10mA. This means the load on the vehicle battery will be roughly 10mA ÷ 2 + 1mA (regulator quiescent current) = 6mA. Over 24 hours, that represents a drain of 0.006A x 24h = 0.144Ah.

As a result, it will take several weeks to discharge a fully charged vehicle battery and thus such a load would be fine to leave connected, as long as the vehicle is driven regularly.

A typical vehicle will draw maybe 30mA from the battery with the ignition switched off. So adding another 30mA will halve the time until the vehicle will no longer be able to turn the engine over. We would be reluctant to leave any load drawing more than this connected long-term.

Fusing

The regulator board will draw a little over 1A at maximum output. The vehicle's reading lamp supply will be fused and a typical fuse would be 5A. Chances are this will have enough excess capacity to handle the added draw, but to be sure you will have to add up the wattages of the lamps on this circuit. You could change the fuse to a slightly higher-rated type if necessary.

However, we had already replaced the vehicle's reading lamps with LED assemblies (as described in the December 2013 issue). This will have reduced the interior light current by at least 1A, as we replaced multiple 3W incandescent lamps with LEDs drawing well under 1W. SC

Pre-made Units

If you don't want to build your own, you can buy pre-made USB sockets that can be simply wired into a 12V automotive supply (eg, Jaycar PS2016, Altronics P0664/P0668/P0676).

However, these are quite bulky and are designed to be fitted to or under the dash. As a result, they're a lot less convenient to use for something like a dashcam and you will also have to rummage around behind the dash to connect them to the vehicle supply.

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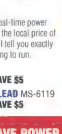

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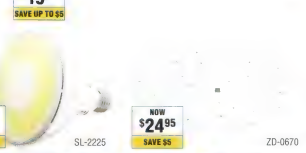

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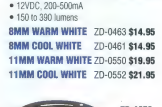

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SL-2225

Outdoor LED Spotlight Globes

Replace your PAR38 halogen or incandescent bulbs. Excellent for outdoor/security sensor lights. 18W. E27 screw cap. Sold individually.

1300 LUMENS WARM WHITE
SL-2225 **WAS $39.95**

1500 LUMENS NEUTRAL WHITE
SL-2227 **WAS $39.95**

1500 LUMENS COOL WHITE
SL-2229 **WAS $39.95**

NOW $24.95

SAVE $5

ZD-0670

LED Replacement Lights

FOR CARAVAN

These replacement lamps will solve all your problems with commonly used caravan lights. Simply bypass the fluoro ballast and connect the lamp with 12VDC directly. 900 lumens, 9W rated.

COOL WHITE ZD-0670 **WAS $29.95**

WARM WHITE ZD-0672 **WAS $29.95**

ZD-0575

DOUBLE POINTS

$69.95 ea

Flexible Adhesive LED Strip Lights

These affordable strip uses the super efficient LEDs to produce 970 lumens of absolute brightness. Great for accent lighting, caravan, 4WD etc. Sold in 5 metre roll and can be cut to sections. 12VDC.

COOL WHITE ZD-0575

WARM WHITE ZD-0577

REWARDS CARD OFFER: 15% OFF THESE SELECTED LIGHTING ACCESSORIES

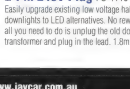
** 15% off the prices listed below with Rewards Card.*

$6.95

12V Halogen Downlight Holder SL-2738

Install your own halogen lamps in the ceiling with this holder. Simply install and fit your halogen globe in. Comes complete with lamp base. Approx cutout 60- 65mm.

$12.95



GU10 Socket to 2-Pin 240V Plug PS-4118

Easily upgrade existing low voltage halogen downlights to LED alternatives. No rewiring needed, all you need to do is unplug the old downlight and transformer and plug in the lead. 1.8m long.

FROM $19.95

Electronic Transformers

FOR LED LIGHTS

Designed for 12V LED lighting products. With constant 12VDC output and features like short circuit, over temperature, etc. they are great for homes or commercial areas.

10W MP-3360 **$19.95**

20W MP-3362 **$24.95**

$24.95

Mains Dimmer Switch PS-4084

Suitable for dimmable LED bulbs or incandescent lights.

- Push on/off or rotate to adjust light level
- 200-240VAC, 1A rated

DON'T LET YOUR BATTERIES GO FLAT

Generate sufficient power to keep your batteries charged during winter storage. These foldable solar panels features 10m output lead with Anderson connectors, alligator or eye terminal connections, charge controller and a durable carry bag. Quick setup and easily stow away when not in use.

REWARDS OFFER: Solar Bundle Deals

CHOOSE FROM:

80W PORTABLE FOLD-UP SOLAR PANEL ZM-9130 **$399**

120W PORTABLE FOLD-UP SOLAR PANEL ZM-9134 **$499**

ADDITIONAL BUNDLE DEAL INCLUDES:

1 X 100AH DEEP CYCLE GEL BATTERY* SB-1695 **$429**

1 X BATTERY BOX WITH ACCESSORIES HB-8500 **$99.95**

2 X IP67 FLEXIBLE LED LIGHT STRIP ST-3950 **$99.95 EA.**

80W PACKAGE DEAL VALUED OVER $1127

120W PACKAGE DEAL VALUED OVER $1227

*SB-1695 not stocked in all stores. Check your nearest store for availability

REWARDS CARD OFFER
80W + BUNDLE DEAL
$999
SAVE OVER $128

REWARDS CARD OFFER
120W + BUNDLE DEAL
$1049
SAVE OVER $178

SOLAR ACCESSORIES

DOUBLE POINTS FOR REWARDS CARD HOLDERS ON THESE SOLAR CHARGERS & METERS

FREE POTATO CLOCK FOR REWARDS CARD HOLDERS* KJ-8937

KJ-8937 VALUED AT $12.95

ZM-9200

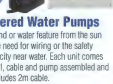
FROM **$49.95**

Solar Powered Water Pumps

Run a garden pond or water feature from the sun and eliminate the need for wiring or the safety aspects of electricity near water. Each unit comes with a solar panel, cable and pump assembled and ready to use. Includes 2m cable.

7V 900MW 140L/HR ZM-9200 **$49.95**

12V 2.4W 200L/HR ZM-9202 **$99.95**



$139

Portable Solar Rechargeable Power Pack

MB-3697

Recharge the built-in 12V 4Ah AGM battery via the 5W solar panel or 16VDC mains power cable (both included).

- Output sockets: 12VDC cigarette socket, 5VDC USB socket
- Two 3W LED lights included

$39.95

Smart Solar Battery Charger

MB-3501

This charger supplies 15V at around 100-120mA of current which is enough to keep an unused 12V battery topped up during winter storage. Ideal for a second car, ride on lawn mower, boat, etc.

FROM **$149**

MP-3129

Solar Charge Controllers

Efficiently charges a vast selection of batteries from a wide range of solar panels. Microprocessor controlled with 3-stage charge modes. Features includes adjustable charging voltage, automatic dusk-till-dawn on/off, overload protection, etc.

See our website for full details.

12V 20A MP-3129 **$149**

12V 30A MP-3722 **$199**

24V 20A MP-3724 **$199**

ZM-9050

FROM **$29.95**

High Efficiency Solar Charger Kits

An easy way to keep your 12V batteries topped up and ready to go when needed. Suitable for use as a trickle charger or as a low current charger. Dust and weather resistant, supplied with 3m long leads terminated with battery clips.

12V 5W ZM-9050 **$29.95**

12V 10W ZM-9051 **$49.95**

12V 20W ZM-9052 **$89.95**

ZM-9016

FROM **$49.95**

Solar Battery Chargers

Weatherproof solar panels ideal for charging sealed lead acid batteries. Mount on a flat surface or on their brackets so it can be moved to follow the sun. Great for use on a yacht, boat or car.

12V 1.26W ZM-9016 **$49.95**

12V 4.50W ZM-9018 **$119**

MS-6172

FROM **$79.95**

Digital DC Power Meters

Suitable for DC operation from 5 to 60V, these meters display and store power usage to suit low voltage DC circuits on boats, caravans, or solar systems.

0-20A RATED WITH INTERNAL SHUNT MS-6170 **$79.95**

0-200A RATED TO SUIT 50MV EXTERNAL SHUNT MS-6172 **$89.95**

USB DATA ADAPTOR MS-6174 **$99.95**

$179

Dual Battery Volt & Current Monitor MS-6176

Don't let your battery run flat ever again! Ideal for boats or caravans/RVs, especially when running refrigeration products or lighting. It is mounted with a single hole, suitable for bulkheads up to 27mm thick. 250A current shunt supplied.

- Audible warning below 11.5V or over 15.5V

DOUBLE POINTS FOR REWARDS CARD HOLDERS ON THESE BATTERIES

SB-1739

FROM **$10.95**

Ni-MH Rechargeable Batteries

High performance rechargeable batteries with no memory effect. Sold in pack of 4.

AAA 900MAH SB-1739 **$10.95**

AA 2500MAH SB-1738 **$18.95**

C 4500MAH SB-1733 **$18.95**

D 9000MAH SB-1734 **$44.95**

SB-2317

FROM **$9.95**

LifePO4 Rechargeable Batteries

These quality LifePO4 batteries offer increased safety and longer cycle life over traditional Li-ion cells. Great replacements in LED torches.

14500 600MAH SB-2305 **$9.95**

18650 1600MAH SB-2307 **$17.95**

26650 3000MAH SB-2317 **$24.95**

FROM **$29.95**

12V SLA Batteries

High quality sealed lead acid (SLA) batteries for standby, emergency and backup power applications. See website for full range.

7.2AH SB-2486 **$29.95** (Shown)

9AH SB-2487 **$39.95**

12AH SB-2489 **$54.95**

18AH SB-2490 **$74.95**

NOW **$29.95**

SAVE $5

Automatic SLA Battery Charger

MB-3527 **WAS $34.95**

Protect your SLA batteries. This smart switchmode charger automatically cuts the charging current to near zero once the battery is charged, whilst still continuing to monitor battery voltage.

- 6V, 12V and 24V charging
- Terminated with alligator clips

ENERGY EFFICIENT 2-IN-1 LED FLOOD/WORK LIGHTS

Introducing our new energy efficient 2-in-1 flood/work lights with detachable stand for portability. Each features high brightness and long life LED, high-strength tempered glass cover with a high-pressure die cast aluminium shell. Ideal for use in warehouse, workshop, hallway or entry ways. IP65 rated.

SL-2876

FROM $34.95

Mains Powered

500 LUMENS 10W
SL-2876 **$34.95**

1500 LUMENS 30W
SL-2877 **$79.95**

3900 LUMENS 50W
SL-2699 **$129**

SL-2817

FROM $34.95

12V Rechargeable

500 LUMENS 10W
SL-2815 **$34.95**

1500 LUMENS 30W
SL-2817 **$89.95**

FREE LIGHT STAND FOR REWARDS CARD HOLDERS SL-2875

SL-2875 VALUED AT $29.95

ELECTRICITY-SAVING ECO PRODUCTS

SMART ENERGY SAVERS

FREE BRACKET CLAMP FOR REWARDS CARD HOLDERS SL-2819

SL-2819 VALUED AT $9.95

$79.95

Rechargeable LED Worklight SL-2809

High brightness, long life LED worklight with tough glass cover. Very bright 500 lumens. 10W, IP65 rated. Mains charger included.

NOW $79.95
SAVE $10

Solar Rechargeable LED Worklight SL-2792 **WAS $89.95**

This handy 5W LED worklight produces an amazing 300 lumens of bright white light, ideal for camp site and emergency repairs. The included rechargeable battery pack doubles as a portable 4400mAh power bank via the 1.0A USB charging port. Up to 3 hours continuous usage per full charge.

- Water resistant, IP54 rated
- Charge time (mains/solar): 5 hr/8 hr

FREE FLOATING LED TORCH FOR REWARDS CARD HOLDERS ST-3457

ST-3457 VALUED AT $29.95

$89.95

Mains LED Floodlight WITH PIR SENSOR SL-2698

Extremely bright LED floodlight with a PIR sensor suitable for use in warehouses, business entry/exit points, or other sensitive areas. 30W 1500 lumens. IP65 rated.

YN-8077

FROM $24.95

8-Port N-Way Ethernet Switches

Unmanaged switches to enhance your network performance and efficiency. Supports auto-negotiation and cable length detection. Mains powered or via USB port.

- Power usage automatically adjusted when link is inactive

10/100MBPS SWITCH YN-8077 **$24.95**

10/100/1000MBPS GIGABIT SWITCH YN-8078 **$64.95**

NEW

BAY15 "3D" LED Globes CANBus Compatible $29.95 ea

No more globe failure warning. These CANBus compatible globes feature a special "3D" type of LED lamp, which provides a wide 360° white light output. Perfect replacement for interior lights, and automotive lamps..300 lumens. 12VDC.

BAY15D STOP/TAIL ZD-0746

BAY15D INTERIOR/NAVIGATION ZD-0748

BAY15S INT./PARK/REVERSE ZD-0749

Desk-Mount LED Magnifying Lamp QM-3548 **WAS $109**

NOW $99
SAVE $10

Magnify and inspect your projects under the ultra bright LED illumination and precision lens for that clear and strain-free viewing. Metal frame construction.

- 5 dioptre, 127(Dia.)mm lens
- Total extended length: 770mm

SUITABLE ROLLING FLOOR BASE QM-3549 **$99.95**

$179

Solar Rechargeable LED Floodlight SL-2808

LED light automatically turns on when darkness falls, and activates when the PIR detects motion. Includes 3W solar panel and 3m cable.

DOUBLE POINTS FOR REWARDS CARD HOLDERS ON THESE LIGHTS

$9.95

Compact LED Worklight ST-3270

Must have for tradies. Fold out hook for hanging, adjustable arm with magnetic base to attach it to any metal surface. Double as a torch - 100 lumens of light. Batteries included. Only 98mm tall.

ALSO AVAILABLE IN YELLOW

Nifty LED Pen Light ST-3466

Handy light with magnetic pocket clip for handsfree operation. Very bright 90 lumens. Requires 3 x AAA batteries. Only 165mm long.

$9.95

$12.95

Handy LED Torch WITH TELESCOPIC NECK ST-3463

A pen-sized torch with super bright LEDs and magnetic head for picking up objects. Extendable to 546mm and goosneck at the end. Batteries included.

LED Headband Magnifier QM-3511

This magnifying headset leaves both hands free and can be worn over prescription or safety glasses.

- Adjustable head strap
- Built-in LED work light
- 1.5X, 3X, 8.5X or 10X magnification
- Requires 2 x AAA batteries

$29.95

SMART SAVINGS OFF THESE ENVIRONMENT METERS

Handheld pH Meter
QM-1670 **WAS $64.95**
An accurate device for checking pH levels in water. Includes 9V battery, pH 7.0 buffer solution and calibration tool.
- Range 1-14 pH (±0.2 pH)
- Resolution: 0.1 pH

REPLACEMENT SOLUTION 50ML
QM-1671 **WAS $8.95 NOW $3.95 SAVE $5**

$49.95
SAVE $15

Ultrasonic Water Tank Level Meter
XC-0331 **WAS $74.95**
Keep an eye on your outdoor water tank from the comfort of your own living room, up to 100m away. The transmitter unit measures the water level using an ultrasonic sensor and thermo sensor. Batteries required.
- Wall mount or free standing

$59.95
SAVE $15

FROM $49.95
SAVE UP TO $15

Non-Contact Thermometers
Safely measure temperature in hot, hazardous, or hard to reach places. Features laser targeting, wide temperature range and auto data hold.

8:1 DISTANCE-TO-SPOT RATIO QM-7215
WAS $54.95 NOW $49.95 SAVE $5

11:1 DISTANCE-TO-SPOT RATIO QM-7221
WAS $119 NOW $109 SAVE $10

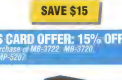
30:1 DISTANCE-TO-SPOT RATIO QM-7226
WAS $199 NOW $184 SAVE $15

QM-7215

REWARDS CARD OFFER: 15% OFF*
*Valid with purchase of MB-3722, MB-3720, MP-5205 or MP-5207

DOUBLE POINTS FOR REWARDS CARD HOLDERS ON THESE NEW PRODUCTS

FROM $64.95



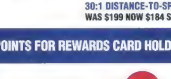
Portable Solar USB Power Banks
Backup battery pack suitable for Smartphones and tablets up to 6,000mAh. Includes USB and micro USB output ports. Recharge battery pack via sunlight or mains power.

4,000MAH MB-3722 **$64.95**
6,000MAH MB-3720 **$119**

$19.95

USB 3.0 SDXC/microSD Memory Card Reader
XC-4752
Great for file transfers at faster speed. Powers directly from USB port and is backwards compatible with SDHC and all older versions of SD/microSD card formats.
- Transfer Rate: up to 80Mbps

See website for compatibility and supported card types



$29.95

USB 3.0 4 Port Mini Hub
XC-4952
This portable and easy to use hub offers 10 times faster transfer speed than USB 2.0 devices.
- Transfer rate: up to 80Mbps
- Compatible with Windows, Mac and Linux

$34.95

35-Piece Electronic Tool Kit
TD-2117
A multi-purpose precision screwdriver tool set consisting 30 bits, two cutters, two pliers, a flexible shaft adaptor and more for those tricky to reach screws. Ideal for electronic DIY and hobbyists. See website for full contents.

FROM $139

Uninterruptible Power Supplies WITH USB
Don't get caught with lost data from power failure. Protect your computer systems with these smart UPS. Features easy to read LCDs which show battery and load value percentage and input/output voltages.

650VA/390W UPS 25min Backup Time* MP-5205 **$139**

1500VA/900W UPS 94min Backup Time* MP-5207 **$319**

** Based on small load. See website for details.*

REGISTER ONLINE TODAY BY VISITING:
www.jaycar.com.au/rewards

$49.95

12VDC Large Portable Stove
YS-2811
Perfect for cooking and/or storing food hot on those long trips. It gets up to 149°C quickly. Insulated design, holds up to 3 litres.

$199

7" Slimline Video Doorphone
QC-3696
Communicate with guests in amazing clarity and allow entry at a press of a button (door strike available separately). Includes monitor and IP44 480TVL infrared camera (for day/night use) with rain shield. Simple to use. Expandable to two monitors. 12VDC.

SPARE 7" DOORPHONE QC-3699 **$149**

GREAT TOOLS TO TUNE UP YOUR CAR & SAVE ON REPAIR COSTS

$39.95

In-Car Battery Monitor XC-0117
Fits all 12VDC cigarette lighter sockets to monitor your car's battery voltage and the inside temperature. Audible and visual alarm.

FREE OBD2 PLUG-IN MEMORY SAVER FOR REWARDS CARD HOLDERS* PP-2140
PP-2140 VALUED AT $5.95

Speedo Corrector Module AA-0376
This smart module alters the speedometer signal up or down from 0% to 99% of the original signal. Extremely useful when you modify your gearbox, diff ratio or change to a large circumference tyre. Automatic input setup selection. 12VDC.

$44.95

$69.95

OBD2 Bluetooth Engine Code Reader PP-2145
No more cables! Read diagnostic trouble codes, both generic and manufacturer-specific with this wireless OBD2 Bluetooth engine code reader. Save precious time and money by diagnosing and fixing certain problems yourself.

NOW $169
SAVE $30

High Performance Jump Starter MB-3750 **WAS $199**
Compact unit with LiFePO4 technology. Able to jump start heavy engines and will work on a flat car battery down to 2.0V. LED torch, 2.1A USB port, mains and car charger included. 12VDC.
- Continuous jump start current: >240A

BUILD YOUR OWN ARDUINO ENERGY METER

TO MONITOR YOUR POWER CONSUMPTION
DOUBLE POINTS FOR REWARDS CARD HOLDERS

MINI PC + ARDUINO =
PCDUINO!
BUNDLE DEALS FOR REWARDS CARD HOLDERS

$39.95

"Eleven" Board XC-4210

Based on the Arduino Uno but better. Top spec ATmega328P MCU, independent prototyping area, visible LEDs, and more. Firmly mounted Micro-USB connector to power your Eleven from most cellphone chargers!

RP-8610

$3.50 ea

10K Potentiometers

Features good solder bath immersion resistance, 300° rotation and standard 18 tooth metric pre-cut actuator shafts. 9mm square PCB mounting. Single gang.

LOG RP-8610

LINEAR RP-8510

FROM $3.25

Cat5e Blue Patch Leads

Suitable for most Ethernet and LAN setups. 1Gbps 350MHz.

0.5M YN-8200 **$3.25**
1.0M YN-8201 **$3.95**
2.0M YN-8202 **$5.25**
3.0M YN-8203 **$6.95**
5.0M YN-8204 **$8.95**
10M YN-8205 **$14.95**
15M YN-8206 **$21.95**
20M YN-8207 **$24.95**
30M YN-8208 **$37.95**

Start building your projects with the latest edition of pcDuino single board mini PC. Two pcDuino bundles at a bargain for both beginner and advanced users.

See website for details

STARTER BUNDLE:

BUNDLE INCLUDES:

PCDUINO V3.0 NANO XC-4352 **$89.95**
MAINS ADAPTOR WITH 2 X USB MS-4085 **$24.95**
USB A TO USB MICRO-B LEAD 1.8M WC-7724 **$9.95**

$69.95

"EtherTen" Board XC-4216

The ultimate network-connected board. It uses ATmega328P MCU and features onboard Ethernet, USB-serial converter, Power-Over-Ethernet support and more. Use it as a web server, remote monitoring and control, home automation projects, etc.

$3.95 ea

WC-6022

Mixed 10-Piece Jumper Leads

For use in arduino projects, school experiments, or RC and other hobbyist activities. All 150mm long.

PLUG TO SOCKET/SOCKET TO SOCKET WC-6021

PLUG TO PLUG WC-6022

$16.95

Resistor Pack 300-Pieces

RR-0680

This assorted pack contains 5 of virtually each value from 10Ω to 1MΩ.

See website for full contents.

- 0.5W 1% mini size metal film

ADVANCED BUNDLE:

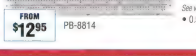
BUNDLE INCLUDES:

PCDUINO V3.0 WITH WI-FI XC-4350 **$119**
7" LCD TOUCH SCREEN MONITOR XC-4356 **$139**
MAINS ADAPTOR WITH 2 X USB MS-4085 **$24.95**
USB A TO USB MICRO-B LEAD 1.8M WC-7724 **$9.95**

Solderless Breadboards

Two sizes of breadboards to suit all your project needs.

300 TERMINAL HOLES PB-8832 **$12.95**
600 TERMINAL HOLES PB-8814 **$19.95**



FROM $12.95

PB-8814

ARDUINO ESSENTIALS

$12.95

ATmega328P Microcontroller

ZZ-8726

An Atmel AVR ATmega328P microcontroller to build customised Arduino compatible projects. Includes 16MHz crystal oscillator.

- Pre-installed Arduino Uno bootloader

$26.95

4-Channel PoE Midspan Injector XC-4254

Power up to 4 EtherTen's (XC-4216) or EtherMega's (XC-4256) with DC from a low cost plugpack across your home or office network cables. It isolates and powers the correct wires automatically.

$34.95

LeoStick XC-4266

A tiny board small enough to plug straight to the USB port without requiring a cable. Features ATmega32u4 MCU with 2.5K RAM and 32K Flash.

- Analogue & digital I/O
- User-controllable RGB LED

$34.95

H-Bridge Motor Driver Shield

FOR ARDUINO XC-4264

This shield provides motor output on 2 H-bridge channels letting the board control the movement and power of two motors independently. Perfect for robotics and motor control projects.

- Drives up to 2A per motor channel

$27.95

ICSP Programmer XC-4237

Program new applications into a wide range of microcontrollers using this ICSP programmer with a USB interface. Compatible with a wide range of microcontrollers, including all Arduino boards.

- Compatible with Windows, Mac, and Linux

128x128 Pixel OLED Display Module

XC-4270 **WAS $54.95**

High resolution, full colour 128x128 pixel OLED module perfect for your display needs including graphics, gauges and many other displays.

- 16,384 full colour RGB pixels
- 28.8 x 26.8mm active display area

ALSO AVAILABLE:

OLED SHIELD with Joystick. XC-4269 **WAS $33.95 NOW $28.95 SAVE $5**

NOW $49.95

SAVE $5

3.2" LCD Touch Module

FOR ARDUINO XC-4280 **WAS $119**

Add an interactive touchscreen display to your existing Arduino projects. Draw lines, text and more. Includes LCD display, 4D Arduino Adaptor Shield, 5-way interface cable and USB programming adaptor with pre-loaded software.

- Operating voltage: 4.5 - 5.5VDC
- Screen display area: 64.8 x 48.6mm
- Screen resolution: 240 x 320 pixels
- 65K True to life colours

NOW $109

SAVE $10

MULTI-BUY SPECIALS!

GREAT DEALS AT UP TO 55% OFF

2 FOR $49

CCTV Power Distributor Box

MP-3351 **$39.95**

SAVE OVER $30

Makes distributing power to multiple CCTV cameras a simple matter. Simply connect a common source up to 30VDC and distribute it to up to 9 slave devices. Screw terminal connection.

- Individually protected PTC output and status LED indicators
- 1-30V AC or DC input

3 FOR $12 SAVE OVER $17

3 FOR $49 SAVE OVER $25

Dual Mains Adaptor WITH NIGHT LIGHT

PP-4039 **$9.95**

Leave a night light on without wasting a power point. Light sensor for automatic on/off.

12VDC Corner Strip Lamp

SL-3465 **$24.95**

The high brightness 12 x LEDs are encased in an opaque diffusing channel and include mounting holes on either end. Wire it up to a switch and away you go. Great for for a caravan or boat.

Top Selling HDMI Leads

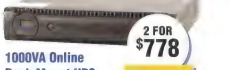
HDMI standard with Ethernet. 99.99% pure copper, nickel plated, triple layer shielding. HDMI 1.4 compliant.

1.5M WV-7915 **$19.95**
2 FOR $29 SAVE OVER $10

3.0M WV-7916 **$24.95**
2 FOR $39 SAVE OVER $10

5.0M WV-7917 **$39.95**
2 FOR $69 SAVE OVER $10

FROM **$19.95**



2 FOR $778

1000VA Online Rack Mount UPS

MP-5212 **$449**

SAVE $120

A true On-Line UPS featuring 2 power sources (battery and mains) to ensure instantaneous transfer time in the event of a power failure. This UPS has a 2U rack height, and can be mounted in standard 19" rack set up or used in a tower configuration.

- 32 mins backup time at high load
- 6 x IEC power outputs

2 FOR $20 SAVE OVER $5

PCB Wash Flux Remover

NA-1070 **$12.95**

A non-flammable and water-based biodegradable solution. Suitable for use in ultrasonic tanks, e.g. metal parts degreasing, flux removal and cleaning of sensitive electronic parts. 1 litre bottle.

2 FOR $23.90 SAVE $10

Cat 5 UTP Splitter

YT-6090 **$16.95**

Save time, money and space! Usually used in pairs, this UTP splitter enables two different devices to share the same Cat5 cable.

Cannot be used to run two computers from one network and not suitable for gigabit networks.

TRADIE MUST HAVE!

2 FOR $59 SAVE OVER $14

Portable Storage Cabinet

H8-6301 **$36.95**

Perfect storage solution for fasteners and other small parts. Unique "double lock" design on each storage box keeps contents in their bins when shut. Commercial grade.

- 12 storage compartments
- 300(W) x 310(H) x 145(D)mm

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Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Savings off Original RRP. Prices and special offers are valid from 24 June - 23 July, 2015.

PRODUCT SHOWCASE

Go-anywhere (literally!) waterproof Fugoo Bluetooth Speakers

There are plenty of Bluetooth speakers around but not many that can claim to be 100% waterproof, 100% dustproof and can give up to 40 hours from their inbuilt batteries.

Fugoo speakers can – they're made from fibre-reinforced resin and solid aluminium – the makers claim they'll probably last longer than you do!

There are three Fugoo models in the range, with price tags from $269.95 to $339.95. A range of accessories including a bike mount, strap mount, multi-mount and a remote control are also available.

You can see a demonstration video at https://www.youtube.com/watch?v=2VKxrs4x2hQ&feature=youtu.be

For more information visit www.fugoo.com

Eagle V7.3 PCB Design Software

Following extensive user research in 2014, CadSoft Computer has released an update to its popular "Eagle" PCB design suite. This package is widely-used in Australia from hobbyists through to major corporations. It is represented in Australia by element14.

Version 7.3 includes many improvements and enhancements based on users' input, particularly the library editor.

It also includes greater integration of IDF-3D capabilities, allowing users to view their design in 3D for free, as well as providing smoother exporting of STEP and STL files through a third party tool.

Contact:
element14
72 Ferndell St, Chester Hill NSW 2162
Tel: 1300 361 005
Website: http://au.element14.com

Tiny Matching Transformer and Band-Pass Filter from Mini Circuits

Clarke & Severn have introduced two new Mini Circuits components. First is a 50 to 75Ω Matching transformer, covering DC to 2300MHz and capable of handling up to 2W input power. It measures just over 30 x 30 x 23mm, with N connectors in and out.

Second is an even smaller band-pass filter covering 4400 to 5200MHz, supporting telemetry, satellite, mobile, military and commercial application bands. It has 1dB (typ) pass band insertion loss and 25dB upper and lower stop band rejection (DC-1800MHz and 7500-12000MHz). It's even smaller at just 3mm x 1.5 x 1mm.

Full specs are available from Clarke & Severn Electronics.

Contact:
Clarke & Severn Electronics
PO Box 1, Hornsby NSW 2077
Tel: (02) 9482 1944
Website: www.clarke.com.au

Bosch makes emergency braking possible using just a video sensor

Emergency braking systems are among the most effective assistance systems in the car. In Germany alone, up to 72 percent of all rear-end collisions resulting in personal injury could be avoided if all vehicles were equipped with them. Now Bosch has developed a stereo video camera with which an emergency braking system can function based solely on camera data. Normally, this would require a radar sensor or a combination of radar and video sensors.

Land Rover offers the stereo video camera together with the Bosch emergency braking system as standard in its new Discovery Sport. This system was developed in intensive and close collaboration between Bosch and Land Rover.

When the camera recognizes another vehicle ahead in the lane as an obstruction, the emergency braking system prepares for action. If the driver does not react, then the system initiates maximum braking.

Contact:
Robert Bosch GmbH
Bosch Service Centre, Postfach 30 02 20, 70442 Stuttgart. Germany **Tel:** (49) 711 400 40990
Website: www.bosch.com

Jaycar stores nudging 100!

Jaycar Electronics have added yet another retail store, bringing the total to 94 bricks-and-mortar stores throughout Australia and New Zealand.

The latest, serving the upper northern beaches of Sydney, is located at 48 Darley St, Mona Vale 2103 and is open 7 days a week.

The store phone number is (02) 9979 1711.

SERVICEMAN'S LOG

I was passionate about my hobbies

Dave Thompson*

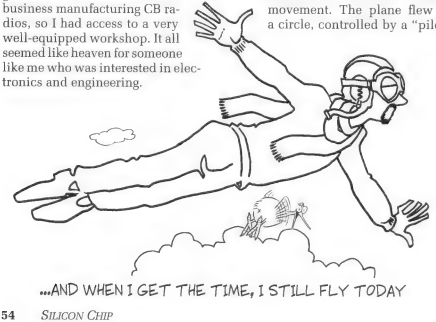
You've got to have more than one string to your bow in this business and my long interest in flying model aircraft means that I can tackle repairs in this field as well. What's more, they make a welcome change from my more-usual computer servicing jobs.

Back when I was in short pants, I was quite passionate about my hobbies, which basically involved all things to do with model aircraft and electronics. It helped that the male side of my family was aircraft/model plane crazy and indeed, my brother and dad were both private pilots for many years. This also helped when it came to the hardware side of things; after all, not many 12-year old lads have the cash to throw around on the latest radio control gear or the parts for building flying models.

Fortunately, dad at one point owned a company making aero-modelling accessories, so access to bits and pieces wasn't much of an issue. What's more, working after school helping to make that stuff was very handy when it came to putting a new model together (or repairing one that had come to grief). Dad also at one time had a business manufacturing CB radios, so I had access to a very well-equipped workshop. It all seemed like heaven for someone like me who was interested in electronics and engineering.

Since many of the imported, brand-name kit models of the time were beyond our budget, most of our models were scratch-built from plans sourced from magazines or model shops. The skills I learned later stood me in good stead for my tenure as an apprentice aircraft engineer and before starting work at the airline, it was already ingrained into me that "near enough wasn't good enough". The standards were high at home when it came to building and flying models and even more-so when dealing with the real thing.

Because the pick of the family radio gear was often being used by my brother, I tended to stick to more off-beat pursuits in the modelling field. Control line techniques were huge back then, whereby model planes were tethered to a handle via two fine-steel lines which controlled elevator movement. The plane flew in a circle, controlled by a "pilot" standing in the middle, and this technique enabled all manner of sports flying without having to purchase expensive radio-control gear.



Obviously you have a lot more freedom with a radio-controlled model but control-line flying certainly had its moments. As a spectator sport, it was exciting watching guys flying combat (where the aim is to snip a trailing ribbon with your propeller as many times as you can in a timed contest), or team racing where two or more teams fly laps, complete with pit stops.

Some of the most spectacular were the speed guys with their asymmetric, streamlined models that could top hundreds of miles an hour. And a pulse-jet speed model flown at night really is something to see.

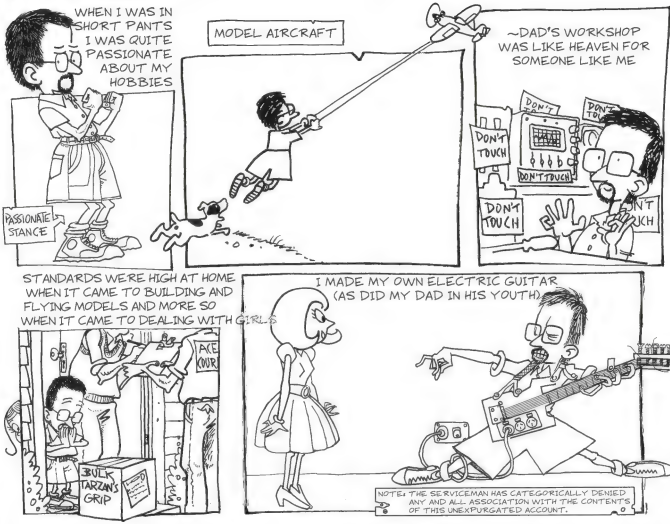
Sadly, this type of modelling has now fallen out of favour for more turnkey endeavours such as drone and toy helicopter flying. What's more, gyros and inexpensive, flight-stabilising electronics have lowered the skill level required to fly them.

Now I don't mean to imply that there is no skill involved in flying today's model aircraft – there is but the technology has changed greatly over the years. While dad always ensured that we had the best equipment to match our models, it was still more prone to interference and failure than today's 2.4GHz digital radio control gear. Even 40 years later, I can recall the times

Items Covered This Month

- Radio-control gear for models
- LG LST-5402P personal video recorder
- The spider under the dash
- Daken M15 electric fence energiser

*Dave Thompson runs PC Anytime in Christchurch, NZ.
Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz



when we could only stand and watch our out-of-control models spear into the ground due to interference, either from an unknown source or because someone in the vicinity had turned on a transmitter using the same frequency as the one we were using.

One of the unwritten rules of model flying was to never give up. There was always a chance that control could be re-established in time to pull the machine out of its death dive but in reality, this was mostly wishful thinking. I recall watching several pilots walking back to the pits area as their planes headed earthward without even trying to regain control. This always seemed to be a very defeatist attitude to those of us who stayed on the sticks right to the bitter end. If you stuck with it, it didn't always end badly; sometimes control was regained just in time to avoid what had seemed inevitable.

Fortunately, modern electronics has all but eradicated that problem. Today's radio gear is extremely reliable and far more immune to interference compared to older sets. Mind you, some radio controllers were pretty good back then; we could literally fly a model out of sight before we were out of range (depending on height) and aside from the few times my own models crashed due to radio failure, we generally enjoyed excellent reliability and service from our Futaba transmitters and receivers.

I've never lost the love of modelling and when I get the time, I still fly today. This interest has led me to experiment with the likes of converting CD-ROM motors to brushless model engines (see SILICON CHIP, July 2012). and similar DIY modelling solutions.

Generally speaking, buying off-the-shelf parts makes sense these days, due to the variety of good-quality components available and their low cost. This makes "rolling your own" seem a bit pointless to some. However, people like me do it for the love of creating something from nothing and while a decent brushless motor can be had for $30, one just as powerful can be made from raw materials in just a few hours. I know which one gives me the greatest thrill.

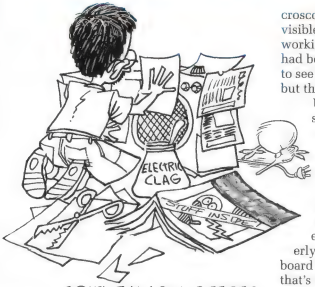
Much the same goes with engine controllers; factories in China churn this stuff out and it has never been easier or cheaper to buy. And yet building my own PIC-based motor controllers gives me so much more satisfaction, even though they might be a little bigger or heavier than the factory-made devices.

This DIY approach is probably due to the environment I grew up in; if I wanted something as a kid, I often made it myself. For example, I wanted an electric guitar but given that the only ones you could buy at the time were way out of my price range, I ended up making my own (as did my dad in his youth). I then yearned for a stereo system but my paper-round income didn't stretch to buying one, so I built my own from magazine articles.

It didn't end there. Electronic ignition for my early British-made cars? No problem; I made my own and lots of other stuff as well.

Controller repair

Fortunately, this background has enabled me to also take on jobs servicing radio-control gear and models. For ex-



~I BUILT MY OWN STEREO FROM MAGAZINE ARTICLES...

ample, some time ago, a friend of mine bought a model chopper. It came with an all-in-one electronic controller, consisting of a radio-control receiver, tail-rotor gyro and speed controller for the brush motor, all crammed into the same little plastic enclosure.

The technology in this device was pretty nifty and it worked very well until one day the owner accidentally shorted out the motor controller wiring and from that point on, it wouldn't even power on properly. Since a new one would cost about $US100 (more than the chopper was worth), he asked me if I would take a look at it.

When I got it on the bench, it turned out to be very similar to a controller used for one of my own choppers. And sure enough, when I took the covers off, the circuit boards were almost identical. I hoped that this would help me find the problem because true to form, I could find no circuit diagrams or any other information about it online.

Removing the boards from the case was simplicity itself once I'd found a Phillips screwdriver that was small enough to fit the tiny screws holding the case together. After removing these screws, the case easily split into two halves, revealing the two controller boards inside. These two boards were sandwiched altogether and connected via multi-pin headers.

After prying the boards apart, I carefully looked over each one under a microscope but couldn't find anything visible that would stop the device from working. Given that the motor leads had been shorted out, I had expected to see a burnt component somewhere but there was nothing obvious.

Undeterred, my next step was to swap the motor controller board with the one from my own controller. When power was applied, the power LED blinked red for a few seconds then changed to a solid green, indicating that the gyro had powered up and stabilised and that everything was operating properly. That meant that the controller board really was the culprit and so that's where I now concentrated my troubleshooting efforts.

When I plugged the faulty board back into the system and tried to power it on, nothing happened at all. This meant that the only thing I could do was to make a "map" of the half-dozen or so surface-mounted integrated circuits on the board and take some measurements to see if I could narrow down the location of the fault.

A clue at last

Once I'd taken measurements at different points, I replaced the board with my good one and carried out the same tests. These gave radically different results and it looked as though one or more of the three motor control output chips had failed. There was certainly nothing coming out to the motor leads from the faulty board, so all I could do was backtrack from there, try to identify the control chips and see if I could find replacements.

One of the chips was for the tail rotor and as measurements around it tallied with the good board, I decided to only replace the two main output transistors. These measured radically differently from those on the good board, so they were almost certainly faulty.

Like many commercially-made electronic devices, the components on the faulty all-in-one controller had had their identification markings removed. Not only is this highly annoying to people like me who want to repair these devices, it's a bit rich given that these things are made in China and that country is often the first in line to reverse-engineer, copy and mass produce others' intellectual property.

However, given what I knew of these devices and the fact that this part of the board controlled a brush motor, I hazarded an educated guess that these components were probably Mosfets. As such, it wouldn't take too much effort to figure out exactly what type I needed to replace them.

These Mosfets were SOT-8 package devices and had to handle a maximum of about 4A, so that was my starting point. I then did some research on similar motor controllers with similar output components and discovered that many used the commonly available IRF7451 Mosfet. A quick look at the datasheet of this component confirmed that its pin-out connections corresponded to those on my faulty circuit board (as far as I could determine) and since they were, um, as cheap as chips (sorry), I ordered a couple online.

However, having replacement output transistors on the way was only half the battle. In the meantime, I had to get the old ones off the circuit board without destroying their solder pads or inadvertently removing any nearby components. I have some reasonably capable de-soldering gear but it wasn't going to be of much use here, considering the size of the boards and the proximity of other components.

After some thought, I decided to use a chip removal method I'd seen demonstrated online. This particular technique is useful if there is space between the component's leads and the circuit board that can accommodate a strip of thin, enamelled wire. The idea is to scratch off the enamel on one end of the wire and feed it through the gap between the leads and the board. That done, the bared end of the wire is then soldered to a nearby substantial solder joint (in this case a common earth) to provide a strong anchor point.

Once this wire was in place, I quickly gave each leg of the chip a bit of heat and sweated solder onto the joints, not caring if it bridged the connections or not. The idea here is to get fresh solder well into the joints without getting things too hot. At the same time, the enamel on the copper wire should prevent any solder from sticking to it.

It was then simply a matter of heating each pin, starting at the furthest from the anchor point, and pulling the copper wire gently out and under each

pin as it heats and de-solders from the board. This lifts it clear of the solder pad just enough to keep it away as things cool down.

I went along, lifting each pin by pulling the wire through until all were free along one side of the chip. I then repeated the procedure on the remaining four leads on the opposite side until it eventually popped clear of the board. Once it was free, I then tackled the remaining chip and soon had it off the board as well.

My next step was to prepare the solder pads for the new chips. This involved applying a small amount of flux to each pad and then applying some fine solder.

The new Mosfets arrived a few says later and the procedure I used for soldering them in place is one I'd used successfully in the past. First, I applied some more flux to each pad. This not only aids soldering but also acts like a glue to help hold the component in place. The part was then pressed onto the pads and positioned carefully to make sure that its pins were correctly aligned.

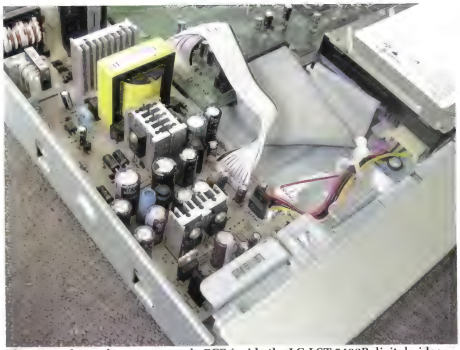
I then just touched each leg in turn using a well-tinned iron, re-tinning the iron's tip as necessary to provide just the right amount of solder. Too much and it blobs and potentially bridges the pins, whereas too little can result in a dry joint.

The flux is the secret here, along with just the right amount of solder. Without flux, the job would be much harder; I purchased a small syringe of flux about two years ago and still have over half of it left, so while it might seem expensive at first, it really isn't. And for those of you about to flood my inbox with advice about the flux "going off", I'm aware of that and store it in the fridge, although that's hardly a good topic to break the ice at dinner parties!

Once the new Mosfet chips had been soldered in, I checked the job under my microscope to ensure that all contacts looked clean and clear. It was then time to power it up. The red flashing LED signalled a good start and then the solid green light came on, confirming that the problem had been solved. And so the chopper lived to fly another day.

LG personal video recorder (PVR)

Faulty electrolytic capacitors in power supplies are a common source of problems in electronic equipment but that wasn't the only problem with a PVR that G. I. of Castle Hill recently tackled. Here's how he got it going again . . .



This view shows the power supply PCB inside the LG LST-5402P digital video recorder, with the hard disk drive at top right. Faulty electrolytic capacitors on the supply board were only part of the problem.

My nephew Daniel recently brought over his non-working LG LST-5402P digital video recorder. I had previously replaced a bulging electrolytic capacitor in the power supply for him and now, just 18 months later, the unit was playing up again.

This PVR is now about nine years old and is quite a nice unit with twin digital tuners, a 160GB Seagate hard drive, a HDMI output and coaxial/optical digital audio outputs (plus others for S-video, component video, composite video and analog audio).

As with its previous fault, the unit could be powered up using the remote control but would then almost immediately turn itself off again. Suspecting more faulty power supply capacitors, I opened the unit up, removed the power supply board and checked all 23 electrolytics in-situ using an ESR meter.

This revealed two suspect 330µF 25V capacitors on the secondary side of the supply – one with an ESR reading of 3Ω and the other 1Ω, whereas readings of less than .01Ω would normally be expected. These were replaced with a couple of 470µF 105°C capacitors that I had on hand and I reinstalled the power supply, confident that that would solve the problem.

And initially, that seemed to be the answer. The unit now stayed on when powered up and could be used as a set-top box to receive TV stations. I also found that it responded to the channel and volume buttons on the remote and that I could navigate through the various menus. However, things quickly went pear-shaped when I navigated to the file menu on the HDD (hard disk drive).

Despite this on-screen menu indicating that the HDD was half-full, no recorded files or folders (apart from the main folder) were visible on the drive. What's more, when I attempted to open the main folder, the unit suddenly switched itself off again.

It did this several more times whenever I attempted to access or record to the HDD, so I figured that the power supply must still be faulty. Despite the ESR meter clearing the remaining electros on this board, I now decided to take a blanket approach and replace the lot. That way, if it still gave trouble, at least I'd know what wasn't causing the problem.

It didn't take long to replace the capacitors but that didn't help. And then the penny suddenly dropped – the faulty power supply had probably corrupted the HDD and it was this that was now causing the machine to

"crash" and switch itself off.

Before swapping out the drive, I decided to check the voltages on its supply connector. They were correct but despite this, I then decided to try powering the drive from an external PC supply. It made no difference so I tried swapping over the drive's IDE cable but that didn't help either.

At that stage, I decided to remove the drive and connect it to a PC, to see if any recorded files could be recovered. Unfortunately, they weren't visible on the PC either and since the recordings were non-critical, I reinstalled the drive in the PVR and tried to reformat it via the on-screen menus. Unfortunately, each time I attempted to do so, the machine crashed.

After several futile attempts, I figured that the best approach would be to reconnect the drive to a PC and reformat it there. The file system used in the PVR was likely to be FAT32 but Windows 7 can only format using the NTFS file system (OK, it can format a FAT32 disk from the command line but only to a limit of 32GB). I went ahead and reformatted it as an NTFS disk anyway, then reinstalled it in the PVR.

This time, when power was applied, an on-screen message appeared saying that it didn't recognise the HDD. It also gave an option to reformat it so I let it go ahead.

After that, it all appeared to work normally and I was able to make a short test recording. This played back without a hitch, so it looked like I really had now solved the problem.

But I wasn't out of the woods yet. I was demonstrating it to Daniel a week or so later and when he hit the fast forward button on the remote, disk error messages immediately flashed up on the screen. And then suddenly, the machine crashed again.

By now, it was apparent that the drive itself was faulty and would have to be replaced – hardly surprising considering it was nine years old and had seen a lot of use.

Fortunately, I'd kept a number of IDE HDDs from old computers and a 200GB Western Digital unit looked like it might do the job, with another 40GB of drive space into the bargain. I formatted it on a PC using MiniTool's Partition Wizard, checked that it was configured as a single drive and installed it in the PVR. It didn't want to know about it, the machine crashing each time during its power-up routine.

Suspecting that the larger capacity drive might be the problem, I reconnected it to the PC, partitioned and formatted it to 150GB and tried again but it still crashed. Some online research then indicated that people had successfully installed larger-capacity HDDs in the LST-5402P PVR but that some drives worked while others didn't. So it looked like the unit was "fussy" when it came to the disk geometry (ie, the number of cylinders and sectors, etc).

I then decided to try a 120GB Western Digital WD1200 (the largest IDE drive I had left). And this time, everything worked with the machine now recording and playing back without a hitch, even on fast forward. What's more, extensive testing has shown the machine to be rock solid, with no further crashing. So the old LG PVR has many years of life left in it yet.

Out of curiosity, I hooked the original 160GB Seagate drive back up to the PC and began checking it using Partition Wizard's "Surface Test" utility. It didn't get very far before it crashed, so the drive had well and truly had it!

It's the spider under the dash!

If a Landrover Discovery won't start, then it's hard to discover anything. Discovering the fault looked like it could be a real problem but the internet came to the rescue, as B. C. of Dungog, NSW relates . . .

My friend Neil has two Landrover Discoveries, one a TDi and the other a TD5. And for some time, his TDi (a 4-cylinder diesel model) had had an intermittent starting problem.

There had been a number of trips to the local garage to get this fixed but true to form, it would always behave itself in the presence of a mechanic. During this time, various possible causes of this fault (ie, those common to most motor vehicles) had been checked out. These included battery condition, electrical connections, starter relay and the starter motor. Neil had noted that only a faint click could be heard from somewhere behind the dashboard whenever the fault occurred.

No auto-electrician

Because we live in a small town, there's no specialist auto-electrician within cooee. And that's how I eventually became involved, due to my previous background in all things electrical and electronic!

My initial research into the problem was done on the internet, where I found some Landrover forums. Goggling "Landrover Discovery TDi starting problems" brought up a page full of possibilities. After sifting through these, it seemed likely that the "spider under the dash" was faulty!

Further reading of one particular post indicated that the ultimate solution was to remove this "spider" and bridge out some of its legs! Fortunately, the poster also described how to do this and I printed his detailed instructions out onto an A4 sheet.

Armed with these instructions, Neil and I decided to give it a go. First, the negative battery terminal was disconnected. We then removed the centre console (12 screws in total) and the car radio/CD player and found a small plastic box. This is the "spider" and it's about the size of a cigarette box and has a multi-pin connector plugged into one end. We unplugged this box and fitted two Scotchlocks to bridge out four of the cables, as per the printed instructions.

That done, we then reconnected the negative battery terminal and successfully test-started the vehicle a number of times. After that it was just a matter of routine to refit the centre console

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Daken M15 Electric Fence Energiser

Electric fence energisers can sometimes be tricky to fix but K. G. of One Tree Hill, SA got this one working in the end. Here's what happened . . .

I was recently asked to have a look at an electric fence energiser which had stopped working. The model concerned was a Daken M15 with an output of 1.5 Joules and capable of energising 15km of fence wire. That might seem quite a lot but in fact this one is recommended only for small to medium-size properties.

When I opened it up, I discovered that it was a quite modern unit in contrast to some I have looked at. It even has a PIC microcontroller to generate the pulses.

Now before I go further, a few words of explanation are in order. An electric fence energiser works in similar fashion to a capacitor discharge ignition (CDI) system as used on an engine. In operation, a capacitor is charged up to a few hundred volts and then discharged into the primary of a transformer, generating a pulse about 50-100µs long. The transformer's secondary has many more turns than the primary and so the voltage is stepped up by about 10 times in the case of an electric fence, or around 50 times in the case of a CDI system.

The pulses from an electric fence are also much less frequent than from a CDI, occurring at intervals of about 1.5s.

The Daken M15 is a mains-powered controller but other models are also available which run from a 12V battery (usually with a solar panel to keep the battery charged). Anyway, with the circuit board out on the bench, the usual visual inspection showed nothing amiss, with no burnt components or bulging electros. Someone else had previously "had a go" though, as a repair job had been done on a track associated with the primary of the transformer.

I changed mains-rated capacitors C1 & C2 but that made no difference. Nor did changing two 470nF 630V capacitors. I then turned my attention to C7, the main reservoir capacitor. This is an 8µF 900V unit rated for pulse operation and a quick measurement indicated that its capacitance was as specified.

I then suspected that the transformer might be faulty so I removed it and measured its primary and secondary resistance and inductance. A video that I turned up on the internet said that the secondary resistance should be 29Ω and this particular unit measured 29.5Ω. This indicated that the transformer was probably OK but just to be sure, I substituted the transformer from a Silicon Chip Electric Fence that I'd built some years before. It made no difference.

Next, I turned my attention to the PIC microcontroller circuitry. Its DC supply was derived from an RC network connected directly to the mains using a rectifier diode, a zener diode and a 470µF electrolytic capacitor. The DC voltage was about 4.7V which was a bit on the low side but well within the ratings of the PIC.

Two LEDs are connected to a couple of the micro's output pins – one green to show the pulses and the other red to indicate if there is a fault. After switch on, the green LED would flash once with a feeble pulse being generated, then the red LED would flash three times followed by a pause, then three more flashes and a pause, and so on. So the PIC micro itself seemed to be doing the right thing.

The big 8µF capacitor is switched across the transformer primary by an SCR, a BT152-800. I didn't have that exact device but I tried a BT138 from the junk box. The results were the same as before – one feeble pulse followed by the red flashing LED. Several other components in the area checked out OK as well, including a couple of 4A diodes and a BC547 transistor which drives the SCR's gate.

This was starting to become frustrating. I then realised I should have checked the voltage on the 8µF main reservoir capacitor much earlier. When I did, it was only about 190V.

Now this electric fence is rated at 1.5 Joules which means that when you do the calculation, the capacitor voltage should be around 600-700V. No wonder the pulses were so feeble. I then traced out the section of the circuit that generates the high-voltage DC from the mains and found that it used a half-wave voltage doubler which by rights should produce about 700V.

Hot on the trail now, I disconnected the second diode in the voltage doubler and with power applied checked the voltage on the first capacitor – one of the 470nF 630V units I'd checked before. It was 340V DC, just what you would expect from peak rectifying the 230VAC mains (more like 240VAC at our place).

That threw suspicion on the second diode in the voltage doubler. I had checked both diodes (D2 & D3) in the doubler earlier by measuring their forward voltage drops and this had shown them to be OK at about 0.5V. I then replaced the second diode, a 1N4007, with one from stock and that was it. The voltage on the 8µF capacitor shot up to about 700V and the green LED kept flashing. There were also now some good loud clicks coming from the transformer.

Although the diode had measured OK at low voltage, it was obviously breaking down under the stress of a couple of hundred volts. Now that the fault had been fixed, I reinstalled the board in its box and left the unit running on the bench for a few hours to soak test it before returning it to its owner.

and the car radio/CD player.

Curious as to what had caused the problem, I dismantled the "spider" and withdrew the small PCB assembly from the housing. There were two relays, a 16-pin DIL IC and quite a few other small electronic components on the board. I also noted that there were a number of obviously dry solder joints and it really was a miracle that the vehicle had started at all in recent times!

As you may have guessed by now, the "spider" is an engine immobiliser module and it has earned a reputation for stopping these vehicles from starting, regardless as to whether the engine is hot or cold. My friend's TDi has also seen plenty of travelling on rough local roads over the years and that, along with the dry solder joints, probably contributed to the problem. Fortunately, it's given no further problems since the immobiliser was bypassed. SC

Ideal for . . .

- **Cordless Power Tools**
- **Model Racing Cars**
- **Battery Appliances**
- **Electric Planes**
- **Just about anything with Nicad or NIMH cells**

INTELLIGENT CHARGER for Nicad and NiMH Batteries

Cheap chargers supplied with the original equipment can – and often do – damage the battery. Proper chargers are usually expensive. This cheap and easy-to-build Nicad/NiMH Battery Charger is suitable for automatically charging a wide range of batteries.

This 'intelligent' charger, controlled by a microprocessor, was designed for high-current and rapid-charge charging applications such as required for cordless power tools and model racing cars. These battery packs are expensive and can be difficult to purchase (it's usually cheaper to buy a new tool!). This charger uses the cell manufacturer's recommended charge method to safely and quickly charge batteries.

Introduction

Batteries for power tools and many other electrical products range from 2.4V to 24V and usually consist of Sub-C size Nicad or NiMH cells. Properly treated, these battery packs should be good for hundreds of charges and could potentially last many years.

The important part of that last statement is "properly treated." Batteries can be ruined by just one incorrect charge.

Unfortunately the battery packs are fairly expensive to replace, sometimes costing almost as much as the entire drill kit, if in fact you can purchase the batteries separately at all. Note that if you can solder, you can rebuild a pack with tagged cells – don't solder directly to batteries though! (See SILICON CHIP, December 2006). If you're really keen, you can even upgrade the battery to the latest Lithium cells (October 2013) but a special charger would be needed.

by PETER HAYLES

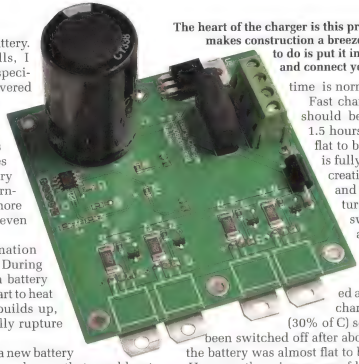
Recently I found my 2-year-old 9.6V cordless drill battery wouldn't perform to its rated

capacity after charging.

I decided to repack the battery. In selecting replacement cells, I researched the manufacturer's specifications on charging and discovered that the battery charger that came with the drill didn't comply with these specifications. The supplied battery charger is a very simple device that applies constant current to the battery pack, with no cut-off, only a warning not to leave "on charge" for more than 14 hours. As we will see, even this is a recipe for disaster!

There is no charge termination method used by the charger. During the recharging process, once a battery reach its full charge, the cells start to heat up and the internal pressure builds up, causing the battery to eventually rupture or vent electrolyte.

Having paid good money for a new battery pack, I decided to design a new charger that would not damage the battery. A better battery charger would require the charger to sense the condition of cells and charge accordingly. I soon realised that the simplest design would be a one-chip design. I selected a PIC controller as it was the smallest and cheapest device available at the time with a suitable analog-to-digital converter.



The heart of the charger is this pre-assembled PCB which makes construction a breeze! Basically, all you have to do is put it in a box, connect power . . . and connect your battery to be charged.

Nicad/NiMH cell characteristics

Even if you don't want to build this charger, you still stand to gain something from this article by understanding how to get the most from your rechargeable batteries.

A cell is defined as a single vessel containing electrodes and electrolyte for generating current. A battery consists of two or more cells, usually connected in series to obtain a higher voltage.

Nicad/NiMH cells are nominally rated at 1.2V for design purposes although they normally develop about 1.25V. Under full charge they require about 1.5V to 1.6V. They can supply very high current and display a remarkably flat discharge characteristic, ie, they maintain a relatively consistent 1.2V throughout discharge. The voltage then drops quite suddenly, and they are almost completely discharged at 0.8V. This is called the "knee" characteristic because of the shape of the graph of voltage against time.

Rechargeable battery capacity is rated in mAh (milliampere-hours). The total capacity of a battery is defined as "C", that is it can supply C mA for 1 hour, or 2C for 30 minutes etc.

Charge rates can vary –

- from trickle chargers (to keep the battery 'topped up') of 3.3% of C to 5% of C
- from a standard charger (a slow current charge) of 10% of C to 20% of C
- or from a fast charger of 50% of C to 100% of C.
- some ultra-fast chargers can go higher than 100% of C but these are normally designed for a specific type of battery.

Slow charges are not meant to be continually applied, as they will eventually overcharge the battery. Since Nicad/NiMH batteries are about 66% efficient, the slow charge time is normally about 8-15 hours.

Fast charges, such as 100% of C, should be terminated after about 1.5 hours, providing the battery is flat to begin with. Once a battery is fully charged, it produces gas, creating a high internal pressure and a sudden rise in temperature. The charger should be switched to trickle charge at this point or the battery will begin to vent and release its electrolyte.

My old battery was rated at C=1300mAh and my old charger was rated at 400mA (30% of C) so the charger should have been switched off after about 4 hours, provided that the battery was almost flat to begin with.

However there is no way of knowing if C was actually 1300mAh or if it had decreased a bit and once the a battery starts to deteriorate, I suspect this becomes a vicious cycle and the battery deteriorates rapidly due to more and more overcharging.

The "Memory Effect" myth

Possibly the biggest myth that exists particularly for Nicad cells is the "memory effect". The myth is that cells have to be completely discharged - otherwise they develop a sort of memory, and can only hold a partial charge from there on.

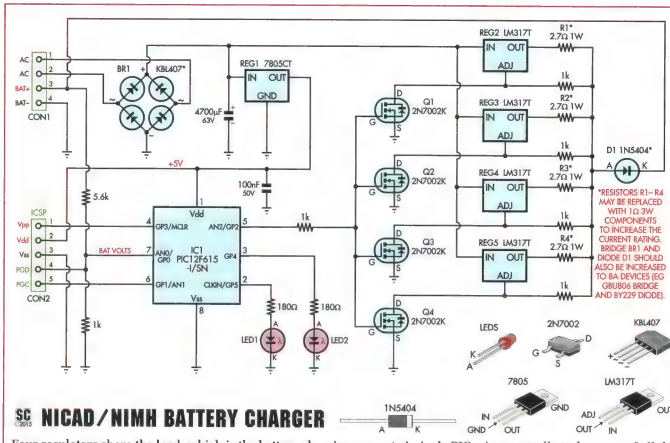
Like all good stories, this one has a grain of truth in it! The myth originated from the early days of satellites when they were using solar cells to charge batteries and because of the orbiting of the craft around the earth, the batteries were subjected to precise charge/discharge cycles many hundreds of times. The effect disappears when the battery cycle is suddenly varied, and it is extremely difficult to reproduce this effect even in a laboratory. In practice the "memory effect" is not a significant problem in home usage.

While it may be OK to discharge individual cells to 0V, it is certainly not recommended to discharge an entire battery of cells. When the battery is discharged below 0.8V per cell, one of the cells is inevitably weaker than the others, and goes to zero first. Then this cell begins to be charged in reverse.

This is easily observable on any battery pack. This creates a more common but less commonly known effect called "voltage depression". The battery performance is greatly affected by the weakest cell, as the cells are all in series.

One other thing – batteries don't like getting too hot or cold; they do not take a full charge and they actually self discharge (even under no load) much faster when over 40° or below 0°. They can build up internal heat when working and this can also cause temperatures inside to increase. Particularly avoid leaving cordless tools inside a hot car for this reason.

They also should be left to cool down for a while after discharge before placing them on charge. Nicad/NiMH



NICAD/NIMH BATTERY CHARGER

Four regulators share the load, which is the battery charging current. A single PIC microcontroller takes care of all the housekeeping, including monitoring the battery voltage to ensure it is not overcharged.

batteries do self-discharge too, as a rule of thumb a battery will hold a full charge (with no load) for about a month or two, although when they get old or hot, they might only last a day.

So therefore:

- You should not discharge your battery before you re-charge it,
- Don't flatten your battery below 0.8V per cell,
- Don't overcharge your battery beyond 100% of C, and
- Nicad/NiMH don't like to get too hot nor too cold (0° to 40°C is ideal)

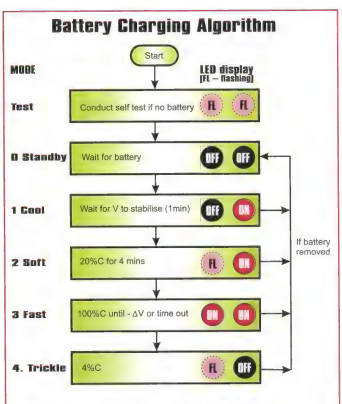
Nicad/NiMH charging

Common values for C for cordless tools and racing cars are in the range from 500mAh to 3000mAh (mostly sub C cells and AA cells). The first step is to determine what C is for your cells. Inspect the cells or contact the manufacturer to determine the cell part number.

In drills, the battery packs can often be easily disassembled. The value for C often forms some of the part number. For my new battery the value for C was 1700mAh. Note that the cell value for C is the same as the battery value for C.

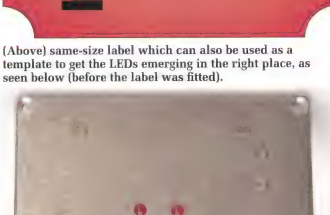
Usually the charge time required is as fast as possible, between 1 and 2 hours. This does not harm the cells, in fact they are designed for it. My battery was capable of taking a fast charge of 100% of C, which equates to 1.7A (Some can take up to a 2C rate). Each of the four regulators must therefore supply around 450mA for a charge rate of 1C.

These two shots show how the PCB is secured to the diecast box lid – it actually mounts on small threaded stand-offs with countersunk head screws used from the top (lid) side. The four regulators must be fitted with insulating washers and bushes to prevent them shorting to the lid.



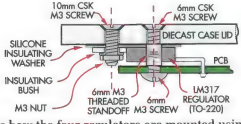
The algorithm flow-chart shows the steps the microcontroller goes through to charge the battery. LED codes are repeated on the front panel (see right)

(Above) same-size label which can also be used as a template to get the LEDs emerging in the right place, as seen below (before the label was fitted).



This value should be good for most readers, and it doesn't really matter if it is a bit less than 100% of C, because the charger will still detect a peak eventually anyway. However, some readers will want to increase the maximum current, and this is described a bit later on.

There are two recommended methods of detecting charge termination, either using a temperature sensor in the battery pack or using a "negative delta V" cutoff system. The temperature technique relies on detecting the sudden rise in battery temperature to shut off the charge. There is nothing wrong with doing this but battery packs do not always come with temperature sensors built in. Furthermore ones that do usually don't sense all of the cells. The negative delta V system relies on the electrical characteristic that the Nicad/NiMH battery voltage peaks and drops about 20mV per cell when fully charged. This charger in its basic configuration will detect a peak of 40mV (per battery) from 2V to 21.5V, thus will charge any battery pack in this range (ie, 2-20 cells or 2.4V to 24V).



Here's how the four regulators are mounted using insulating washers and bushes; also how the PCB mounts to the case lid via four threaded stand-offs and screws.

Another point to consider is the requirement to let a battery cool down. If the battery has just come off discharge and is hot, it may take a minute or so for the charge to begin to start. Additionally, new batteries may show false peaks in the first four minutes of charge, as various cells synchronize their charge state. For this reason the charger starts with a slow "soft start" charge for four minutes to allow the battery to cool and get past this point.

Normal operation of the charger is fairly straightforward: the charger is switched on and both LEDs will flash once for self test. The charger uses a threshold of 2V (open circuit voltage) to recognize that a battery has been connected. The

charger will progressively start and peak the battery. The battery can be left on trickle charge indefinitely.

Powering the charger

The method of powering the charger depends on what you want to charge – that is, the voltage and current rating of the batteries.

As specified, the charger is intended for low-voltage cordless power tools with batteries of, say, 9-18V. And as it has a bridge rectifier built in, you can power it with either AC or DC. Of course, the current rating of the transformer or DC supply needs to equal or exceed the required charging current.

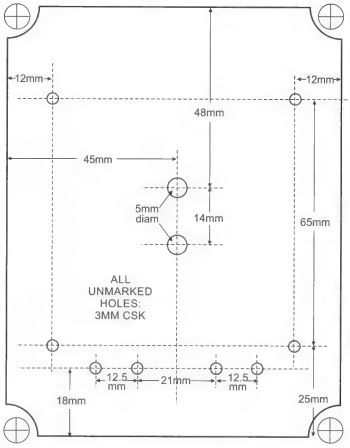
For batteries up to 7.2V (six cells) a 12VDC or 9VAC supply rated at 2A or so would be ideal (as you can see from our photos, we used a perfectly good 12V/3A supply from a perfectly bad laptop PC!).

For higher voltage batteries, you'll need a higher-voltage supply – say 24VDC or 15-16VAC for 12-14V batteries (again, look at surplus laptop supplies – there are plenty around with 16-18V output at 3-4A) but if you're wanting to charge a 24V battery, you're going to need something higher – say 30VDC or 24VAC.

It is strongly suggested that a "plugpack" supply or transformer be used; these keep the "bitey bits" out of harm's way, especially for beginners.

If you must (and you know what you are doing) a transformer could be used and mounted inside a (much larger) case with the PCB.

In this "opened out" shot, the lid-mounted PCB is at the top with the output on the left and the socket for the AC or DC supply on the right.



Here's a template to help you drill out the diecast case. It is intended for a standard 117 x 92 x 55mm case.

Operation

A constant-current supply is generated by several parallel linear regulators and pulse-width-modulated by a PIC12F615-I/SN microcontroller. The microcontroller senses the battery voltage and internally uses an analog-to-digital converter to read the battery voltage.

The microcontroller has its own 5V regulated supply (delivered by a 7805 regulator) and displays the current charging status on two LEDs.

Four LM317T regulators connected in parallel will each maintain 1.25V between their OUT pin and ADJ pin. A 2.7Ω SMD resistor in the output limits the current to a constant 1.8A, or about 450mA per regulator. These resistors also help to ensure that the load current is spread evenly between the regulators.

A power diode in series with the output makes sure that current can only flow in one direction; it will be reverse-biased and therefore stop current if a charged battery is connected with the circuit not powered.

A voltage divider, consisting of a 5.6kΩ and 1kΩ resistor monitor the battery voltage, while ensuring that even with a high-voltage battery (eg, 33V) the input to the PIC cannot exceed 5V (the input limit).

From this point, virtually all circuit operation is controlled by the PIC. It monitors battery connection and if one is present, waits for one minute for the voltage to stabilise (which could be required if the battery is hot from hard use). It then provides a "soft" charge for four minutes, fol-

Increasing the charging current

As supplied, each regulator has a 2.7Ω SMD resistor in its output. As well as limiting the charging current to ~450mA per regulator (or 1.8A total), these resistors help to ensure that the load is shared equally between the regulators.

If you have a higher-rated battery (eg, ~5000mAh, which can handle higher charging currents), by lowering this to a 1Ω 3W SMD resistor (2512/6432 size), the total charging current will approach 5A.

The bridge rectifier (BR1) would need to be changed to, say, an 8A GBU806 (same pinout), as would D1 – a BY229 is also rated at 8A.

We haven't tried these changes, by the way, but the output current is well within the regulators' ratings.

The only rider on this is that dissipation will also increase, so simple heatsinking to the case lid might not be enough. At a minimum, we'd also add some heatsinking compound to ensure as much heat as possible is removed. An alternative might be to use a "real" heatsink.

lowed by a fast charge. The fast charge terminates when the microprocessor senses the "delta V" point of battery charge or in worst case, if the charge time is exceeded.

It then enters a "trickle" charge state which is intended to maintain the battery at full charge until it is used.

LEDs

Two LEDs, driven by the microcontroller, give a visual indication of which mode the charger is in. These modes, with LEDs on, off or flashing, are shown on the front panel of the charger.

Construction

Because the PCB is supplied already built and tested (no need to solder those pesky SMDs!) the only construction required is to put the charger in a suitably drilled diecast box and connect input and output wiring.

We used a diecast box not so much for its strength (though it certainly has that!) but because the diecast box provides heatsinking for the four LM317T regulators.

The only fiddly bit about this is that the drilling for these, the two status LEDs and the four PCB mounting screws must be pretty good! Use our diagram as a guide (or even a template if your photocopier is accurate).

We mounted the PCB upside-down in the case, so that it "hangs" from the lid rather than mounts on the bottom. This is to allow the two status LEDs to poke through the front panel. While using the lid does not give quite the same heatsinking as using the box itself, it's more than adequate for the task.

All screws through the lid were countersunk so the label could be glued flat on the panel. There's not a lot of depth available in the case with the large electrolytic capacitor hanging down, so we used the shortest M3 countersunk screws we could find (6mm). These go into tapped 6mm stand-offs, with four more M3 screws (5mm pan or flat head, this time) securing the PCB to the stand-offs.

If you find (as we did) that the stand-offs aren't quite long enough to accommodate both screws, you could use 10mm types or place a 3mm inner diameter washer each side of the stand-offs to make them just that little bit longer.

The four LM317 regulators need to be insulated from the diecast box in the usual way – our diagram shows how the flat insulating washers and the round insulating bushes (one set per regulator) ensure there is no shorting to the case.

Input and output leads depend a lot on your application. As we mentioned, we used a surplus laptop supply so simply drilled a hole in one end of the box and used a panel-mounting DC power socket which matched that on the supply.

The output merely goes to some heavy-duty polarised figure-8 cable with spade connectors on the far end (again, because these suited our application). You might prefer to use crocodile clips or some other plug/socket arrangement. That's up to you.

Input and output leads all screw into the same PCB-mounted terminal block. The PCB is clearly labeled so you shouldn't be able to mix them up (did someone mention Murphy?).

And that's it! As we mentioned earlier, the PCB is tested when assembled so it should work straight away.

SC

And now for something completely different . . . Here's something from the past that you will enjoy far into the future!

Radio, TV & Hobbies April 1939-March 1965

Every article to enjoy once again on DVD-ROM

This remarkable archival collection spans nearly three decades of Australia's own Radio & Hobbies and Radio, TV & Hobbies magazines. Every article is scanned into PDF format ready to read and re-read at your leisure on your home computer (obviously, a computer with a DVD-ROM is required, along with Acrobat Reader 6 or later (Acrobat Reader is a free download from Adobe).

For history buffs, it's worth its weight in gold. For anyone with even the vaguest interest in Australia's radio and television history (and much more) what could be better? This is one DVD which you must have in your collection!

Wheredyageddit?

The pre-assembled and tested PH-00001 PCB comes from Shapely Electronics Design (www.shapely.asia) and sells for $50.00 inc GST, +P&H.

All other components – the diecast box, DC power socket, standoffs, silicone insulators and grommets, etc, are commonly available from electronics retailers.

Download the front panel from siliconchip.com.au

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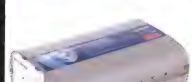

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NEW!

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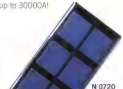
Allows you to connect a load (such as a camping fridge) to one battery whilst ensuring the second battery remains charged for starting the engine.



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Huge 4.8A current output. Ideal for charging two phones or tablets at once.

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Power all your cameras from the one box!

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Sturdy Aluminium Tool Case

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Tablet for illustration purposes

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$309 SAVE $70

M 8310 0-30V 20A

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Wide voltage range and high current output!

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Bench top power supply for use in servicing, repair and design. The low noise switchmode design offers excellent regulation for high current requirements. Offers the flexibility of both wide adjustable voltage & current range. Size: 336W x 87H x 214Dmm.

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SAVE 26%

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Q 1074A

X 0111

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Smartphone Repair Kit

Everything you need to disassemble and repair most smartphones and tablets. Great for DIY screen or battery replacement. See web for contents list.

BARGAIN!

T 2164

$29.50

Bargain Non Contact Thermometer

Affordable and high spec IR thermometer for measuring temperatures without contact. -50°C to 500°C. 12:1 resolution. Great for technicians, mechanics, even food safety.

NEW!

$49.95

Q 1283

2 year warranty!

Iroda® 100 Watt Gas Iron

Cordless Go-Anywhere Soldering Iron & Blow Torch. One-click piezo ignition. Two hours use from a full tank! T 2599 Kit Includes:

- Blow torch tip • Hot knife tip • Hot air tip • Solder
- Sponge • Carry case
- T 2451 gas to suit $7.50.

SAVE $20

$59

T 2598 Iron Only

SAVE $20

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T 2599 Full Kit

BARGAIN!

T 2173

$24.95

30pc Precision Driver Kit

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$12.95

T 4015

Magnetic Mat Prevents Loose Screws!

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Q 1250

Measure wind speed & temperature easily.

A compact thermometer & anemometer with max speed of 108km/h. Great for ventilation monitoring, experiments etc. Includes battery. Very easy to use!

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$8.95

T 1330

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With handy iron stand built in.

SAVE 25%

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T 1310A

Desktop Iron Stand

Weighted diecast base.

T 2152

SAVE 20%

$34

19pc Field Technicians Tool Kit

Includes an array of handy tools: • Needle nose pliers • Bent needle nose pliers • Serrated pliers • Side cutters • Bull nose pliers • Flat pliers • Fine tip tweezers • 3 x philips #00, #0, #1 • 3 x flat blade 2.0, 2.5, 3.0 • 6 x star/torx T6, 7, 8, 9, 10, 15

Build It Yourself Electronics

K 5528

Currawong 2x10W Valve Amplifier Kit

The Currawong amplifier is a tried and tested valve amplifier circuit which has been adapted to components which are readily available. Each channel uses two 12AX7 twin triodes for the preamp and phase splitter stages and two 6L6 beam power tetrodes in the class-AB ultra-linear output stage. It performs very well, with low distortion and noise.

Features: • Two pairs of 6L6 beam power tetrodes • Two pairs of 12AX7 twin triodes • 2x10W RMS power output into 8 Ohm loads • Remote volume control

Supplied with: This kit includes all valves, PCB, componentry, acrylic board cover, transformers & panels. **It does not** include parts to build the enclosure. We suggest building your own to suit your own style.

K 6130

NEW KIT!

Remote Switch Timer Kit

$89.95

(SC November '14) Schedule your appliances to turn on and off with this handy kit, designed to be used in conjunction with the Altronics A 0340 remote mains switch (included). Perfect for switching lights on and off when you go on holidays, turning on small motors, pumps etc.

K 5181

'Classic-D' Amp Module Kit

$55

(SC November '12) A rugged and reliable Class-D audio amplifier producing up to 250W into 4Ω. Class-D amps are commonplace amongst consumer equipment offering high power and efficiency. Low distortion <0.01%. Based on the IRS2092 audio amp chip.

K 5508

Headphone Amplifier Kit

$40

(SC May '11) Boosts the volume output of your device & significantly improves fidelity - lowering distortion & noise. Requires 2xAA batteries

K 7520

NEW KIT

Resistance/Capacitance Decade Box

$119

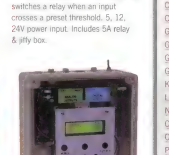
(SC Aug '14) This decade box kit is a really handy device for trying capacitor and resistor values in-circuit before you select the final value to solder.

K 6009

Take stop motion photos with your camera.

$50

(SC Jan '09) Flash Camera Trigger Kit. Take pictures at precise moments from 1ms to 9.99s after a trigger. Triggering can be from the included electret mic or other sensors. Requires 9V battery.



K 4005

Threshold Voltage Switch Kit

$33

(SC Jul '14) A versatile design which switches a relay when an input crosses a preset threshold. 5, 12, 24V power input. Includes 5A relay & jiffy box.

K 6120

SAVE 15%

Smart Fan Controller Kit

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(SC July '10). Regulates the speed of up to eight 12V DC fans. Measures up to 4 temperature points & smoothly controls fan speed.

K 6005

40A DC Motor Speed Controller Kit

$60

Ideal way to control the speed of a DC motor without the need for expensive gearboxes or inefficient resistors. Featuring: • PIC micro and efficient MOSFET's • Excellent speed regulation • Soft start • 8 memory settings • Low battery alarm • Variable pulse width modulation • 12-24V DC input

K 6340

SAVE 20%

Mini Switching Regulator

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(SC Feb '12) Outputs 1.2-20V from a higher voltage DC supply at currents up to 1.5A. It's small, efficient and cheap to build.

K 2553

Digital Audio Signal Generator Kit

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(SC March '10). With S/PDIF coaxial and optical output - plus dual analog outputs! Incredibly low distortion (typically <0.06%). Ideal for RMS and music power testing of amps or speakers; testing DACs & crossovers. Requires 4xAA or 9V plugpack.

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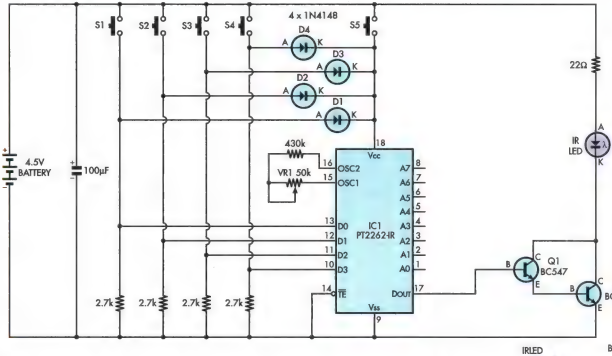
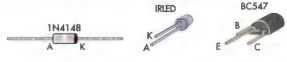
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.





4-channel IR remote switch with toggle and latch modes

This 4-channel IR remote control has a two-stage (Toggle and Latch) output, selectable by an SPDT switch. The circuit is based on a PT2262-IR encoder paired with a PT2272-M4 decoder (both from Princeton Technology Corp). The encoder chip is specially designed for infrared remote control applications and its pulse encoded waveform runs at 38kHz.

The transmitter is built around IC1 (PT2262) and an IR LED. IC1 has eight bits of Tri-state address pins (pins 1-8), providing 6561 address codes, thereby reducing the possibility of any code collision and unauthoried code scanning. The four channels of the transmitter are controlled by four momentary contact switches, S1-S4. These are tied to data input pins 10-13 and pin 18 of IC1 via diodes D1-D4.

Once a switch is momentarily pressed, data will be encoded (according to the address pins which can be set high, low or floating) and modulated onto the 38kHz carrier frequency-generated by the oscillator inside IC1. The output signal at pin 17 ia buffered by Darlington pair transistors Q1 & Q2 which then drive the IR LED. The range is about 15 metres. VR1 is used to adjust the carrier frequency to 38kHz.

Switch S5 switch is employed only in the latch mode to reset the channels.

The receiver is based on IC2 (the PT2272-M4 decoder), IRD1, an infrared receiver module, IC3 & IC4, which are both 74HC74 D-type flipflops serving as toggling latches, and IC5, a 74HC194 4-bit shift register employed as a regular latch. IRD1 picks up the signal, demodulates it and feeds it to IC2 to be decoded. IC2 initially checks whether the received signal is a valid transmission; it must match the address setting at address pins 1-8.

After two consecutive valid transmissions, IC2 drives data pins 10-13 according to the data bits received and also pulls pin 17 high to light LED5. Switch S1 selects whether the output is a toggle or latch.

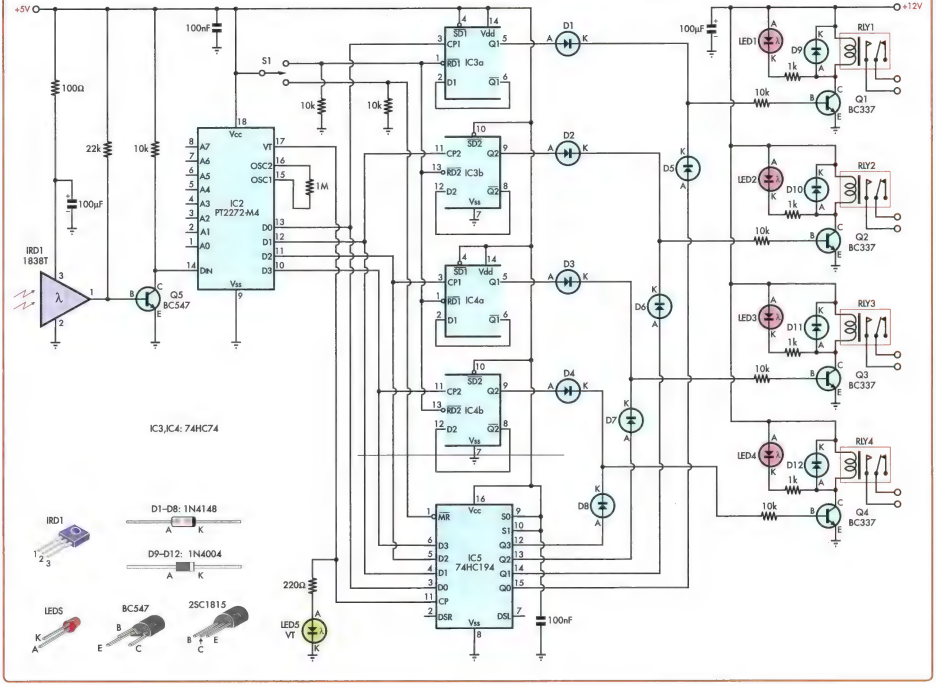
When set to toggle, the flipflops in IC3 & IC4 act as toggles to turn relays RLY1-RLY4 on or off. Each relay can can then be turned on or off by one of switches S1-S4 of the transmitter.

When switch S1 of the receiver is set to latch, IC5 will serve as a latch and IC2 and IC3 will be held in reset. In this mode, momentary pressure on the control switches of the transmitter will cause one of the relays to energise and remain on. But when another switch of the transmitter is pressed, the relay which was on will be turned off.

This means that the four channels are not independent like the toggle state. However, it is possible to turn two or more relays on simultaneously by pressing two or more switches of the transmitter at the same time. To turn the relays on in this mode, switch S5 of the transmitter should be momentarily pressed.

Note that all the address pins of IC2 must have identical coding to those of IC1 in the transmitter, otherwise the circuit will not work.

Mahmood Alimohammadi, Tehran, Iran. ($60)


+5V
+12V
100nF
100µF
S1
100Ω
22k
10k
1M
IRD1
1838T
Q5
BC547
IC2
PT2272-M4
IC3a
IC3b
IC4a
IC4b
IC5
74HC194
IC3,IC4: 74HC74
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
LED1
LED2
LED3
LED4
RLY1
RLY2
RLY3
RLY4
Q1
Q2
Q3
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D9–D12: 1N4004
LEDS
BC547
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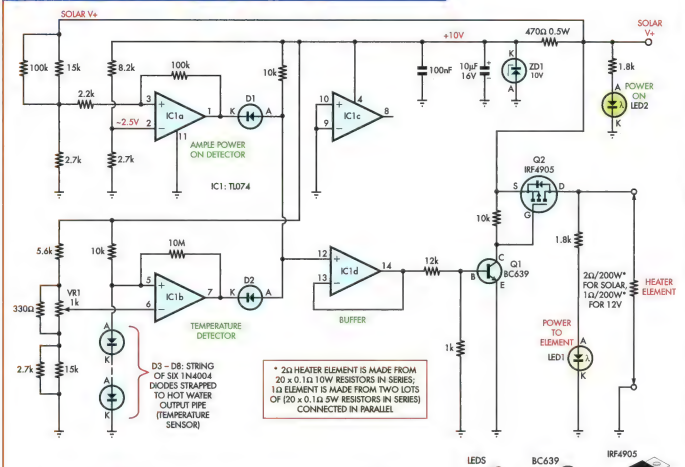

Temperature-controlled solar hot water tank

This circuit controls the output from a 12V solar panel array which is used to drive a 2Ω 200W heating element in a hot-water tank. The control element is an IRF4905 Mosfet (Q2) which has a very low on resistance.

Three op amps in a TL074 quad package are used to control the circuit. IC1a monitors the DC output from the panel and its pin 2 is connected to a reference voltage of 2.5V, derived from the 10V zener diode, ZD1. If its pin 3 goes above pin 2, the output at pin 1 will be high. If it is less than 2.5V, pin 1 will be low and diode D1 will conduct, pulling pin 12 of IC1d, a voltage follower, low. This will turn off Q1 and Q2 will also be off, preventing any power from being delivered for hot water.

MAY THE BEST contribution WIN!

As you can see, we pay $$$ for contributions to Circuit Notebook. Each month the BEST contribution *(at the sole discretion of the editor)* receives a **$150 gift voucher from Hare&Forbes Machineryhouse.** That's yours to spend at Hare&Forbes Machineryhouse as you see fit - buy some tools you've always wanted, or put it towards that big purchase you've never been able to afford!

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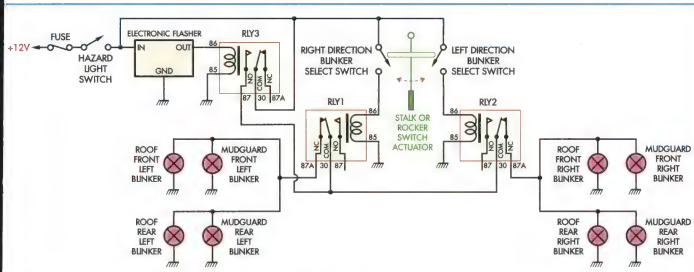

Hazard lights & turn signals for a tractor

This circuit was devised to add to left and right turn signal indicators to a tractor so that it could be driven on public roads.

The tractor already had hazard lights so two relays were added to interrupt the 12V supply to the left or right side of the hazard lamp circuit. When the tractor driver wishes to turn right, the stalk switch (or rocker switch) energises relay RLY1 which disconnects the 12V feed of the flasher unit to the left blinker lamp circuits while the lamps on the right side continue to blink, thus indicating that the vehicle is "turning right".

Similarly, when the tractor driver wishes to turn left, the stalk switch energises relay RLY2, which disconnects the 12V feed of the flasher unit to the right blinker lamp circuit. The lamps on the left side continue to blink, thus indicating that the vehicle is "turning left".

Most old existing blinker canisters rely on the lamp load to work so it is necessary to replace them with an electronic flasher unit and have it drive a relay if the number of lamps on the tractor exceeds the highest rating of 220W.

Peter Howarth,
Gunnedah, NSW. ($45)

Editor's note: note that it is necessary for the hazard flasher circuit to be switched on for the turn signal mode to work.

David Francis is this month's winner of a $150 gift voucher from Altronics & Jaycar

This allows the panel to charge a 12V battery, if necessary

If the panel voltage is high, pin 1 of IC1a is high and D1 will allow pin 12 of IC1d to be pulled high. Note that the 100kΩ and 2.2kΩ resistors connected to pin 3 of IC1a provide a degree of hysteresis so that the circuit does not toggle the output of the Mosfet rapidly. So when pin 12 of IC1d is pulled high, its output goes high also, pulling up the base of Q1 to turn it on. This pulls the gate of Q2 low, turning it on and supplying power to the heating element.

IC1b is used to monitor the temperature of the water tank. Its pin 5 monitors the voltage across a string of diodes strapped to the output pipe (and buried under the insulation) of the hot water tank, as a temperature sensor. VR1 allows the operating temperature of the tank to be set. The voltage drop across the diodes will be reduced as the tank temperature rises and vice versa.

If the tank temperature is low, pin 5 of IC1b will be high and if it is above the voltage set at pin 6 by trimpot VR1, pin 7 will go high, allowing pin 12 of IC1d to be pulled high by the 10kΩ resistor.

Hence, diodes D1 & D2 act as an AND gate, only allowing the Mosfet to be turned on if the solar panel voltage is high and the tank temperature is low.

David Francis,
Kilburn, SA.

MISS THIS ONE?

Published in Dec 2012

2.5GHz 12-Digit Frequency Counter

with add-on GPS accuracy

Wow! 10Hz - >2.5GHz in two ranges; 1us - 999,999s with a 12-digit LED display. It's a world beater and it's the perfect addition to any serious hobbyist's bench – or the professional engineer, technician, in fact anyone who is into electronics! You'll find it one of the handiest pieces of test gear you could ever own and you can build it yourself.

All the hard-to-get bits (PCBs, micros, LEDs, panels, etc) are available from the Silicon Chip On-Line Shop.

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Final part of this fascinating series by Dr David Maddison

The BIONIC EYE

In the first part of this series, Dr David Maddison looked at the history and recent advances in the "holy grail" of vision impairment research – allowing the blind to see. There's a lot of work currently going on in search of that lofty goal . . .

There are a several ongoing bionic eye research projects around the world. They mostly involve retinal implants or cortical implants. In Australia, there is one of each type of device under development.

Beyond implants and also described here, there are sensory substitution devices such as the Brainport, Eyeborg and The vOICe. The learned skill of human echolocation that requires no hardware whatsoever is also described. Sensory substitution is the process whereby one sense such as sight is replaced with another sense such as touch.

A simple example of this is a blind person's cane.

There is not room in this article to discuss all the projects under development so some representative cases are discussed below, including retinal implant devices that are either in clinical trial or commercially available. The two Australian projects will be discussed in greater detail.

Devices not described because they have not yet reached clinical trial are a Stanford University group, "Photovoltaic Retinal Prosthesis", Nano Retina (Israel), the Boston Retina Implant Project and various groups in Japan.

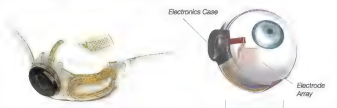
Retinal and cortical implants

ARGUS II

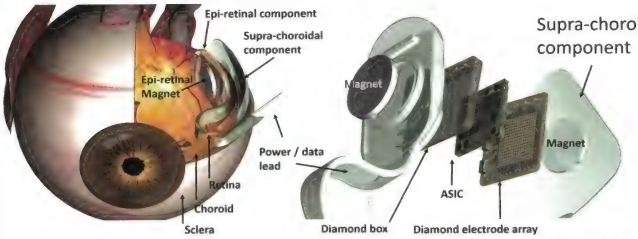
The Argus II, manufactured by US company Second Sight www.secondsight.com, is one of only two retinal implants that are currently approved by regulators and commercially on the market. It has a 10x6 electrode array. While a pioneering device, the best result for visual acuity achieved so far is 20/1260 which is still legal blindness according to the WHO standard that blindness is greater than 20/500 (normal vision being 20/20). Nevertheless, it does improve the quality of life for its users. The Argus III device is under development and will have 200 electrodes.

Among activities that patients have reported to be able to undertake with the device are:

- Locate doors, windows, elevators;
- Follow a pedestrian crossing across a street;
- Avoid obstacles;
- Find utensils on a table or when serving food;
- Locate coins;
- Track the motion of a napkin when cleaning;
- Sort light and dark clothes;
- Locate people in front of them (but not see the details of a face);
- Track a ball; track players on a field;
- Locate an overhead light in an entrance way;



Argus II retinal implant showing its location within and on the eye. In addition to the implant, a patient also wears glasses containing a video camera and a video processing unit worn on the belt.



Schematic view of BVA high acuity device with 256 electrodes. The illustration at left shows the location of the device within the eye; at right is an exploded view of the device.

- Locate the light of a candle or light bulb and
- Watch fireworks.

Bionic Vision Australia

This national consortium of researchers from the Bionics Institute, the Centre for Eye Research Australia, NICTA, the University of Melbourne and the University of New South Wales is developing a retinal implant.

The main purpose of the BVA device is to initially help people with retinitis pigmentosa and age-related macular degeneration.

It consists of a camera and vision processor device as well as the retinal implant which receives signals wirelessly from the vision processor.

An objective with the BVA device was to preserve any minor residual vision that someone may have and minimise damage to the retina. Devices planted in the epiretinal or subretinal spaces (either directly above or directly below the retina) can have problems that can lead to the deterioration of what little retinal function may be left, therefore BVA decided to use the suprachoroidal space for implant.

Utilising the suprachoroidal space, a world-first by BVA, provides a "buffer" between the electrodes and the neural tissue which is analogous to the way the cochlear devices are implanted and why they have long term stable performance.

The first implant of an experimental device by this group was conducted in 2012 and was an early prototype 22-electrode device, which has now been implanted into three patients as part of a clinical trial which was successfully completed. The devices were implanted in the suprachoroidal space. The purpose of this device was to enable a vision processor to be developed based on feedback from the patients in order to allow optimisation of the stimulation algorithms. See a video of the patient using the device – *"Dianne Ashworth 12 months on, 2013"* at https://youtu.be/jQEZiAuL_AE and *"Dianne Ashworth bionic eye prototype testing, 2014"*, https://youtu.be/6EmleCs0KGY.

The prototype devices enabled the trial patients to identify basic shapes, letters and numbers; tasks not possible with whatever residual vision they had. The devices were removed at the conclusion of the trial in August 2014.

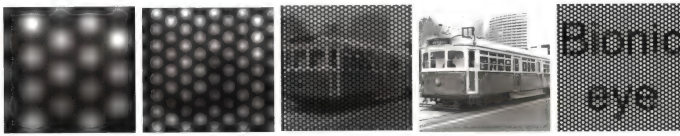
Three devices are currently under development. The first to be developed for production was a 44-electrode device based on the prototype 22-electrode device, expected to enter clinical trial in mid 2015.

A wide-view device with 98 electrodes is also being developed which has hexagonal electrodes which enable more effective stimulation when using a high electrode density.

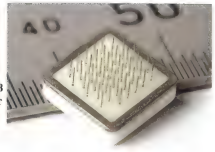
Beyond that there is a 256-electrode high-acuity device under development but currently there is not sufficient funding to continue this development.

The 256-electrode device will have electrodes so closely spaced they will need to be in much closer contact to the neural tissue and electrode stimulation from the suprachoroidal space will not be suitable. So part of the device will be placed epiretinally, despite some disadvantages with that location as described above. There are future plans to expand the electrode count to 1,000.

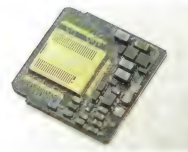
Novel approaches to electrode fabrication are required for such high electrode counts. It so happens that deposited diamond film is very biocompatible and can also be doped



Simulated phospene patterns and images for Bionic Vision Australia devices for an image of old Melbourne tram at 16 phosphenes, 64 phosphenes and 1,000 phosphenes (pixels) and original image and "Bionic eye" text at 1,000 phosphene resolution.



Electrode array (tile) of Monash Vision Group device which during installation is pushed down onto the surface of the brain such that the 43 electrodes enter layer 4 of the V1 area of the visual cortex.



Back side of the 9x9mm "tile" showing control circuitry of tile which contains 650,000 transistors and 43 digital-to-analog convertors. The entire implant is hermetically sealed.

to provide electrical conductivities ranging from that of an insulator to that of a conductor. The device will be effectively hermetically sealed in a diamond "box".

It is expected that the high degree of biocompatibility with diamond will minimise problems with conventional devices in the epiretinal location.

For further details of the high acuity device see the video with Professor Steven Prawer: "*The Diamond Bionic Eye*" – https://youtu.be/jOokLf3frwE

Monash Vision direct to brain bionic eye

Monash Vision Group (MVG) is a collaboration between Monash University, Alfred Health, MiniFAB and Grey Innovation and is under the leadership of Professor Arthur Lowery.

The device under development is a cortical implant. It is intended for people with non-functional retinas, damaged optic nerves or missing eyes that are not candidates for a retinal implant but it can also be used to provide vision where blindness occurs for a variety of other reasons. The implant is expected to enter clinical trials in one year.

The device will consist of an electrode array or "tile" implanted on the visual cortex V1 area of the brain. That tile will receive wireless signals from a digital processor attached to the side of a user's eyeglasses.

The glasses will also contain a video camera to visualise what a user is looking at.

The implanted tile is 9mm x 9mm in size and contains 43 2mm-long platinum-iridium electrodes, corresponding to a 43-pixel image.

On the back side of the tile is the wireless receiver and processing circuitry containing 650,000 transistors and 43 digital to analog convertors.

Each electrode is individually addressable and configurable with a variety of parameters to ensure each electrode performs optimally and that the settings can be changed to support improved stimulation algorithms as they are developed.

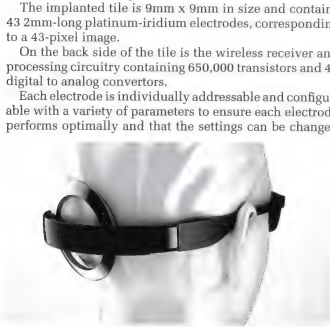
Note that with implanted electrode arrays, whether they be in the retina or the visual cortex, that there is a minimum practical spacing since electrical currents will stimulate adjacent electrodes if the spacing is too little. Additionally, if the electrodes are spaced too close together there are too many electrodes and too little neural tissue.

Multiple tiles will be implanted to improve resolution. It is intended that up to 11 tiles will be implanted in a patient giving a resolution of 473 pixels. Multiple tiles will be used since it is difficult to fabricate a single larger device with the required curvature to conform to the brain, apart from the fact that each brain has a slightly different shape.

The precise location in which the tile is to be implanted is determined using the process of functional magnetic resonance imaging, fMRI (see *Interfacing to the Brain, Silicon Chip, January 2015*) is used to find the area of the visual cortex associated with high resolution vision from the fovea.

When the area is located, a check is made to ensure no major blood vessels will be penetrated and then the tile is pushed down allowing the electrodes to penetrate into the brain to their full depth of 2mm.

The location into which the electrodes penetrate is a part of the V1 visual cortex called layer 4. Layer 4 is the area of V1 that receives most of the input from the lateral geniculate body.



Headset of Monash Vision Group device that contains a camera, video processor and wireless coupling to connect to implanted tile.

Pixium Vision

French company Pixium Vision (www.pixium-vision.com/en) has a retinal implant, the IRIS device which in its commercial version will have 150 electrodes and is currently undergoing clinical trials. Its PRIMA system will have up to several thousand electrodes and will begin clinical trials in 2016.

Retinal Implant AG

A German company Retina Implant AG (http://retina-implant.de/en/default.aspx) has a retinal implant device called the Alpha IMS that has received European regulatory approval for marketing. It has 1,500 photodiodes and matching stimulation electrodes in a 3x3mm package. The photodiodes eliminate the need for an external camera.

SENSORY SUBSTITUTION DEVICES AND TECHNIQUES

Seeing with your tongue – Brainport

Brainport (www.wicab.com/en-us/) does not directly connect with the nervous system of a person but is an assistive technology to allow people to see via sensory

Brainport device showing processing unit, eyeglasses with camera and plate to be put on mouth to stimulate tongue with visual information.

substitution. Brainport uses a video camera to generate a pattern on a device that a user puts on their tongue.

It uses an array of 400 points to generate a pattern on the tongue corresponding to a visual image. Users eventually learn to interpret the sensation on the tongue as sight via the process of neuroplasticity, whereby the brain rewires itself to accommodate new ways of working.

(See videos of this device in use: *Brainport Vision Device helps a blind man "see"* https://youtu.be/xNkw28fz9u0 and *Emilie Gossiaux painting with the BrainPort* https://youtu.be/1xYi9oZMVWI).

Seeing colour with sound – Eyeborg

It is not a bionic eye in the sense that it is not interfaced with the visual system but artist Neil Harbisson was born with an extremely rare vision disorder called "achromatopsia" or total colour blindness and can only see in shades of grey.

He has had a device made for him that converts colours to sound and even lets him "see" in the infrared and ultraviolet.

The Eyeborg can convert 360 colours into sounds and can indicate colour saturation via volume level. The user has a choice of perceiving colour via either a logarithmic or non-logarithmic sound scale.

In Neil's device he says that with his infrared detection capability he can sense if there are movement detectors in a room or if someone points a remote control at him and with his ultraviolet sensing ability he can determine whether or not it is a good day to sunbathe!

Neil used to wear the device but has recently (since March 2014) had the device, called an Eyeborg permanently attached to his skull and this enables more nuanced hearing of the sound as the sounds are transmitted through his skull to his ears.

The "antenna" which is the stalk onto which the camera that sees the sound is mounted, also has Bluetooth and WiFi capability so he can send and receive images. He is

Neil Harbisson, said to be the world's first cyborg and who can hear colours with his prosthesis.

able to "hear" images sent to him. To charge the device he plugs it into a USB port and a charge of a few hours lasts three to four days; however he wants to develop methods to charge the device by his body.

In 2004 he was declared by the media to be the world's first cyborg. After a long battle with the UK Passports Office who initially refused to allow a passport photograph with the device attached, he won the right to be photographed with the device after arguing that the device was part of his body. He is also now an advocate of cyborg rights.

The Eyeborg device has also been developed as a wearable, non-implanted device and donated to blind communities to enable them to have a sense of colour. Neil helps people become cyborgs via his Cyborg Foundation (www.cyborgfoundation.com) (video on that site as well) which has also donated Eyeborgs to the blind.

If you want to experience hearing colours as sound there is a free Android App to enable this, with an Apple iOS App under development. www.eyeborgapp.com.

For a talk by Neil Harbisson see *The Human Eyeborg: Neil Harbisson at TEDx Gateway* https://youtu.be/d_mmwrb-DGac The Eyeborg development site is at www.eyeb.org.

It is written in Catalan. Google may be able to translate it but the translation process did not work at the time of writing.

There is also an unrelated Eyeborg project at http://eyeborgproject.com/ which is essentially a video camera mounted within an eye socket with no integration to the body. There is also a descriptive video at that link which also looks at other advanced prosthetic devices.

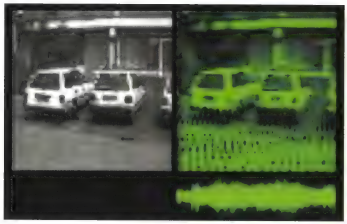
Seeing with sound – The vOICe

There is a project to enable blind people to see with sound by converting camera images into sounds ("soundscapes") which the user learns to interpret.

The vertical axis of an image is converted into frequency and the horizontal axis into time and stereo panning as the software scans across the image to create the soundscapes. The technology is the invention of Dutch engineer, Dr Peter B.L. Meijer.

It is hoped that with sufficient training users will be able to learn to interpret – and perhaps even experience – the soundscapes as sight.

The technology is called The vOICe (Why? "Oh, I see!")



Original camera image (left) and image reconstruction from The vOICe "soundscape" giving an idea of the resolution that might be seen by a skilled user of the technology.

and is privately owned intellectual property but it is supplied free to non-commercial users.

Users (and that includes SILICON CHIP readers who are interested in experimenting with this!) are able to assemble and configure their own set-ups from commercially available equipment. Windows and Android devices are currently supported, and soon there may come suitable augmented reality glasses for convenient hands-free use.

A relatively high resolution compared with retinal and cortical implants is theoretically possible for those that learn to interpret the soundscapes.

Soundscapes are generated at a resolution of 176x64 pixels (ie, representing over 11,000 pixels) for a one second soundscape. However, due to hearing limitations the real resolution could be somewhere between 1,000 and 4,000 pixels for complex images, similar to between a 32x32 and a 64x64 pixel array as shown in the illustration in Part 1 of this feature.

Hearing limitations are in part the result of a general frequency-time uncertainty in sound: there is a fundamental limit to how well one can simultaneously extract frequencies and time points of sound elements in arbitrary complex sounds. However, someday in the future it may be possible to overcome this limit by skipping over-the-air soundscapes altogether, using the same scanning and panning scheme of The vOICe to directly stimulate nerves in the cochlea with high resolution cochlear implants.

This device has the advantage that it is not implanted and therefore there is no risk of medical complications from surgery, device failure or foreign body reactions. It is very low in cost and has a high resolution comparable to or better than current implanted devices.

Moreover, neuroscience research has shown that the visual cortex of blind users over time gets recruited for processing sound (and touch).

In one experiment at Harvard Medical School in Boston, temporarily disrupting activity in the visual cortex of an experienced late-blind user of The vOICe with a technique called TMS (Transcranial Magnetic Stimulation) also disrupted the visual interpretation of soundscapes of objects.

In other experiments it was shown that a brain area called LOtv (lateral-occipital tactile-visual area, which is activated by shapes that are seen or touched but not by natural sounds) became responsive to soundscapes that encoded object shapes.

The Holy Grail is now to devise efficient training paradigms that not only bring improvements in functional vision but that for late-blind users also reliably lead to "truly visual" percepts from soundscapes.

There is a very extensive and detailed web site describing the technology along with demonstrations at www.seeingwithsound.com. Also see a somewhat-dated video on the technology featuring the inventor at *Seeing with Sound (sensory substitution for the blind)* https://youtu.be/I0lmSYP7OcM and a recent video *The vOICe Lets The Blind See With SOUND!* https://youtu.be/MjMhvfC11TY. See also *Grasping objects with The vOICe (sensory substitution for the blind)* https://youtu.be/XuosPzluCRg

Human echolocation

Certain individuals have developed a method of sensory

INCORPORATING THE RETINAL CODE

Much retinal implant research has focused on improving the devices' electrode count, apart from mechanical, electronic and bio-compatibility issues. There is also another important factor to be taken into account.

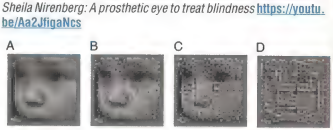
Recall that the retina itself processes visual data before the information is sent back to the brain via the ganglion cells. Whatever processing takes place is important in how the brain interprets the visual data. With a retinal implant this processing step is typically left out and the ganglion layer is directly stimulated via the prosthesis.

While the specifics of what coding is done by the retina is too difficult to understand from first principles at this time it is possible in a research environment to determine what code is output from the eye (in the form of pulse trains) for a certain input stimulus such as a face, for example. Without knowing what is actually happening in the eye researchers have reverse-engineered the output code to match what the eye does.

When a visual stimulus is encoded the way it is done naturally in the eye and then presented to the prosthetic device, a superior result is achieved compared with when no encoding is done.

A question that might be asked is, if this natural processing is not encoded in device hardware, will the brain be able to learn to do this processing itself via the process of neural plasticity?

An explanation of this research in more detail is available at *Sheila Nirenberg: A prosthetic eye to treat blindness* https://youtu.be/Aa2JfigaNcs



A) Original image presented to eye B) image reconstructed from encoder C) image reconstructed from retina from encoded data D) image reconstructed from retina without the use of an encoder.
Diagram credit: From Nirenberg and Pandarinath http://physiology.med.cornell.edu/faculty/nirenberg/lab/papers/PNAS-2012-Nirenberg-1207035109.pdf

perception not normally found in humans and that is echolocation. This is a form of sensory substitution where one sense is developed to replace another lost sense.

Echolocation, or sonar, is the method by which bats, toothed whales and dolphins and some other animals "see" in certain environments for navigation and hunting.

They do this by emitting a sound and then listening for the echo which gives then information about the range of an object and its texture. In addition, the direction of an object can be determined, as with normal hearing, by the difference in arrival time of the reflected sound in each of two ears.

The direction of the outgoing beam can also be altered up and down enabling a three-dimensional view of the environment that is akin to vision.

A bat's sonar system has a surprisingly high resolution and can resolve points that are as little as 0.3mm apart.

There are several people on record who have managed to train themselves to use echolocation. They do this by using their tongues to make a loud click and listening for an echo in the same way as echo-locating animals. Since humans do not have the specialised apparatus for making sounds or analysing them in the same way as animals, it is not likely they can see as well with sound as animals do – but they can nevertheless develop a useful picture of their world.

Remarkably, blind people who have developed an echolocation ability have been found to be using the visual cortex of the brain, normally responsible for vision, for processing the acoustic information about the environment rather than the parts of the brain normally used for hearing.

There is a video here of a man who is able to ride a bicycle and do solo hikes in the forest using echolocation among other remarkable achievements. *Human echolocation - Daniel Kish, "Batman"*: https://youtu.be/A8lztr1tu4o

See also *Human echolocation-1* https://youtu.be/GVMd-55j2EXs and *Human echolocation demonstration-2* https://youtu.be/3pM6YYDjb4o. This same individual is teaching other people the technique of human echolocation: teaching the blind to navigate the world using tongue clicks – *Daniel Kish at TEDxGateway 2012* https://youtu.be/ob-P2a6Mrjs

Biological solutions

Apart from electronic solutions to blindness, biological cures are also under investigation. One example is whole eye transplants which are currently under development.

In an eye transplant by the far the biggest challenge is connecting the optic nerve but significant developments are currently being made in the area of nerve regeneration.

Another promising area of research is to inject human embryonic stem cells into the eye. Such therapy has been used with some success to treat age-related macular degeneration (AMD) or Stargardt's macular dystrophy. Gene therapy is also under investigation.

In the medium to long term future it may even become possible to grow spare body parts from one's own genetic material.

Conclusion

Great advances have been made in bionic vision and vision via sensory substitution. Much of this can be attributed to continued advances in microelectronics, computer processing power, materials science and a continued improvement in understanding how the brain works.

The realisation that neuroplasticity can effectively rewire the brain allows for alternate approaches to vision using different sensory inputs such as sound and touch and the possibility that such methods will lead to a very real sense of sight should not be excluded since neuroplasticity allows non-visual data to be mapped to the visual cortex as though it were real vision.

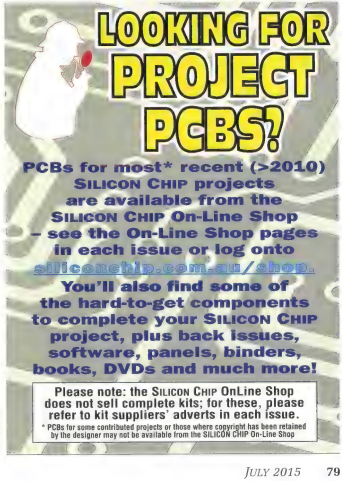
Great challenges still exist, especially with resolution, however much lower resolution vision than what is natural can still lead to profound improvements in a vision-impaired person's life. SC

Have an Android device?

Then try teaching yourself to see with sound using the free app from Google Play: https://play.google.com/store/apps/details?id=vOICe.vOICe

A rising bright line gives a rising tone, bright specks give short beeps, the folds in your curtains and the books on your bookshelf yield rhythms, and the bright rectangle of a window sounds like a noise burst. The dark rectangle of a door opening gives a "gap" in the noise of the surrounding wall. Just experiment and push your perceptual limits.

market://search?q=pname:vOICe.vOICe



Ultra-LD Mk.4 200W P
Power Amplifier: Prev

We have been working on a revised version of the very popular Ultra-LD Mk.3 amplifier module. While the circuitry will be very similar, it will be on a smaller PCB employing SMDs for the low-power circuitry of the front-end, with new small-signal transistors to substitute for those that are now hard to get or no longer made.

By NICHOLAS VINEN

THIS IS THE fourth power amplifier module in our Ultra-LD series and the third based on ON Semiconductor's ThermalTrak power bipolar transistors. While the specifications for this module will be similar to the last, it has been considerably re-designed and there are a number of advantages compared to the Mk.3 module.

Like its predecessors, this amplifier module has extremely low levels of distortion (including at higher frequencies), along with a substantial output power capability of 135W RMS into an 8Ω load, 200W RMS into a 4Ω load and substantially higher music power figures. We are using the same output transistors; they're still state-of-the-art.

It's hard to fault the existing Ultra-LD Mk.3 module on its noise or distortion performance so while we aim to provide an incremental performance improvement, one of the the main reasons for this new design is to substitute more modern components for those which are quite dated. Specifically, the Toshiba 2SA970 low-noise input transistors used for the input pair are increasingly hard to find and the BF469/BF470 high-voltage transistors are now obsolete.

As is the case with so many parts these days, modern signal transistors are available mostly in SMD packages; through-hole components, especially new devices are becoming less common.

So being virtually forced to use at least a few SMDs in the new design, we decided to change the entire front end and some of the output stage to SMDs.

Besides better availability and lower prices, there are several other advantages to using surface-mounting parts. Firstly, this allows the small signal section to be much more compact which means both a smaller PCB and less chance of RF and hum pick-up due to shorter tracks. In theory, there may also be a small improvement in performance due to lower parasitic inductance.

Also, because the parts no longer have leads which must pass through the board, we can employ a ground plane on the underside. This makes a very effective shield for the input stage so it is far more immune to any stray magnetic fields, whether they are from the output stage tracks, output filter inductor or anything else in the chassis (eg, a mains transformer).

Using SMD transistors for the voltage amplification stage (VAS) and its associated constant-current source also means that we can use the copper on the PCB for heatsinking, eliminating the bulky flag heatsinks which we used on those transistors in the earlier designs.

Extra features & changes

While updating the module, we've taken the opportunity to add some features that we've been asked for in the past and change some design decisions that we felt were not optimal.

Firstly, we have added an offset adjustment trimpot to the design. This allows the input transistor offset voltage to be adjusted down to around ±0.1mV. This makes the amplifier much more suitable for driving a transformer with a low-resistance primary winding. The board will have provision for the required output voltage clamping diodes as well.

Secondly, the extra diode featured in the January 2013 issue (Performance Tweak For The Ultra-LD Mk.3 Amplifier) is now present on the board. This makes the unit's performance much better when it is driven into hard clipping; or should we say, less bad. It effectively makes recovery from negative-voltage clipping as clean and fast as that from positive-voltage clipping and thus improves signal symmetry and reduces ringing under these conditions.

For this role, we are using an MMBD1401A SMD diode which has a low base capacitance of 2pF at 1MHz.

We have also changed the relatively hard-to-get Molex power and output connectors to the commonly available pluggable terminal block type. However we have yet to confirm whether these will give the best possible performance for the speaker terminal connections as we've previously encountered issues with dissimilar metal junctions in connectors affecting linearity (see the panel on page 65 of the

The new Ultra-LD Mk.4 power amplifier uses SMDs for the front-end circuitry, resulting in a more compact PCB design. This view shows a prototype version; the final version will have a few minor changes.

April 2012 issue, in the Ultra-LD Mk.3 Amplifier Pt.2 construction article).

However, our testing so far shows that these connectors are certainly sufficient for the power input and are more convenient to wire up than the Molex types.

New transistors

Of the seven small signal transistors in the Ultra-LD Mk.2/Mk.3 design, six were arranged in pairs: two PNP input transistors, two NPN current mirror transistors and two PNP constant current source control transistors. The new SMD transistors (HN3A51F [PNP], HN3C51F [NPN]) we have specified are two to a package and have virtually identical performance to the 2SA970 low-noise transistors used in the earlier designs.

This 6-pin dual package has much better thermal tracking between the two transistors. This is especially useful for the input pair: any differential heating will cause a shift in the differential base-emitter voltage between them and thus affect the output offset voltage. With both transistors in a single package, this should be essentially eliminated. It also means that any interference picked up by the two transistors should virtually cancel due to their close proximity.

The benefit to the current mirror is smaller but its operation does depend on good base-emitter voltage matching which is a feature of these dual transistor packages.

We've replaced the BF469 (main VAS transistor) and BF470 (its constant current source) with FZT696B and FZT796A transistors respectively. These are in SOT-223 packages which are capable of up to 2W dissipation with suitable PCB heatsinking. In operation, they normally dissipate well under half a watt, so this is not an issue. Still, it's desirable to keep them at a stable temperature to avoid changes in performance as they warm up or cool down.

Compared to the BF types, the FZT transistors have a slightly higher transition frequency (70MHz vs 60MHz), much higher peak collector current rating (1A vs 100mA), slightly lower but still sufficient voltage rating (180V vs 250V) and dramatically higher current gain (150-500x compared to ~50x). This means that the open loop gain and open loop bandwidth of the amplifier should be higher and in an ideal world, this will result in greater distortion cancellation.

We've also improved the open-loop bandwidth by replacing the BC639 in the first stage of the VAS Darlington with a BC846, the surface-mount equivalent of a BC546. The BC639 was originally chosen for its voltage

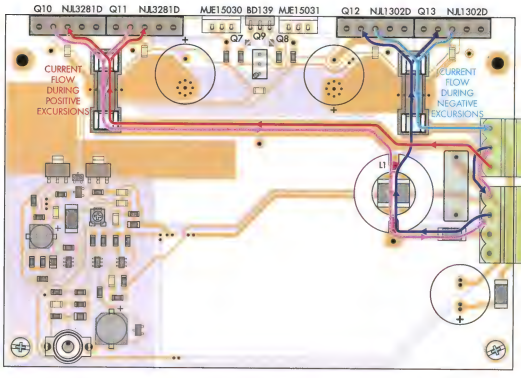


Fig.1: the current prototype board with the high-current flow paths shown for low-frequency signals (ie, at frequencies where onboard bypassing capacitors do not supply much current). Since many of the current paths overlap and flow in opposite directions, this provides a high degree of magnetic field cancellation thus minimising inductive coupling between the output and input stages. Note that the output transistor emitter resistors are directly under the fuseholders (ie, mounted on the bottom of the board).

rating of 80V; its relatively high collector current rating is not important since the collector current is limited by a series resistor.

The BC846 has an identical collector-base voltage rating and only a slightly lower collector-emitter voltage rating of 65V but it has better linearity and a much higher typical h_{FE} of 200-450, compared to just 40-160 for the BC639.

Preliminary testing shows that this new amplifier is capable of producing very low distortion figures (well below the limits of our analysis equipment at some frequencies and power levels) but we have not finished tweaking it yet. At this stage, we are simply not able to quantify how good it is.

Stability & compensation

While greater open loop gain is desirable as it can result in better distortion cancellation via global feedback, it does come with challenges. We've had to go to greater lengths to stabilise this amplifier compared to previous revisions. Due to the very high open loop gain, we've had to add a capacitor across the VAS current-limiting resistor (in series with the collector) to reduce local feedback due to the Early Effect (where gain changes to some extent with collector voltage).

We've also had to use a slightly more complex VAS compensation scheme, similar to the 2-pole version used in the Mk.3 amplifier but with an extra capacitor across the ground resistor.

We've also incorporated components to allow for high-frequency roll-off within the feedback loop. Specifically, this consists of a step circuit, ie, a series combination of resistor and capacitor across the main feedback resistor.

We're also looking into tweaking the values used in the output RLC filter. This filter has a dual purpose; it acts as a Zobel network, which is a type of snubber at the output that helps stabilise the amplifier and it also isolates any extra capacitance in the speaker and its wiring from the amplifier, which could otherwise cause enough phase shift in the feedback loop to trigger oscillation.

But you may recall from our articles on the Ultra-LD Mk.3 design that we discovered that the magnetic field generated by the filter inductor also interacted with the magnetic field caused by currents flowing in the PCB itself and thus its value and orientation affected performance.

With this new design, the magnetic loops are tighter and so this should be less critical. We're hoping that this means we can reduce some of the filter component values (keeping them sufficiently high for stability) and in the course of doing so, also reduce the inductor resistance and thus the amplifier's output impedance. This should improve its damping ratio and possibly also reduce the possibility of the inductor's magnetic field interacting with anything else in the amplifier. At the time of writing, this is still being investigated.

Magnetic cancellation

As you may be aware, all of our low-distortion amplifier PCBs have been laid out carefully in order to avoid the magnetic fields caused by high Class-B currents from interacting with the rest of the components on the board and injecting distortion. This is an especially difficult problem because of the fact that the Class-B currents are essentially half-wave rectified versions of the output waveform.

In theory, the Ultra-LD Mk.4 has the best magnetic cancellation of any of our designs, as the main Class-B current paths are directly on top of each other. In other words, when current is flowing into the board along one layer of the PCB, the same current flows along the other side of the board in the opposite direction and thus the magnetic loop is only as wide as the PCB is thick (~1.5mm).

This arrangement is shown in Fig.1. Current flowing from the positive supply to the loudspeaker via the upper pair of emitter-follower output transistors is shown with red and magenta arrows, while the equivalent flows for

continued on page 87

Vintage Radio

By Ian Batty

Stromberg-Carlson's 78T11/79T11 transistor set

The 78T11 was Stromberg-Carlson's first Australian-made transistor set. It was a 7-transistor design built onto a metal chassis with point-to-point wiring and it offered excellent performance.

STROMBERG-CARLSON'S US parent commenced operation in 1894, when Alexander Graham Bell's patent for the telephone expired. At the time, Stromberg and Carlson worked for the Bell Telephone Company (later AT&T) and they each invested $500 to begin manufacturing equipment, primarily subscriber sets ("home" and business telephones) for sale to independent companies. Their home base was in Chicago and Stromberg-Carlson quickly established a reputation for reliable equipment and stable prices.

Stromberg-Carlson Australia bore little resemblance to its American parent. The company began by importing receivers from the United States in 1927, before commencing local manufacture in 1928. Their radios mostly used local components.

Stromberg-Carlson made components both for their own radio receivers and for sets made by other companies. Their brands included Stromberg-Carlson, Audiola and Crosley. Between 1939 and 1945 Stromberg-Carlson continued with radio manufacture, though at a much slower rate. They also produced telephones and telephone switchboards for the Australian Army.

With the advent of television in the mid-1950s, Stromberg-Carlson also tried to establish itself in that market but failed to make inroads. The 1958-1959 78T11/79T11 transistor radio sets described here were among their last Australian products.

Main features

The 78T11/79T11s are both large sets and fall into a category that I think of as "picnic portables". The 78T11 was Stromberg-Carlson's first transistor set and was released in 1958, a year after Australia's very first transistor radio, AWA's model 891. In terms of styling, the 78T11 resembles both Sony's early TR72 and Raytheon's 8TP which also had top-mounted controls.

Unlike the Sony's simple dial, the 78T11 offers a slow-motion tuning drive, albeit using a rather "agricultural" spindle that (when it works) drives the tuning knob's rim via a rubber grommet.

The back of the case flips open to reveal the circuitry. Like many sets of its day, it uses a pressed-and-stamped steel chassis, with the low-power transistors mounted through the chassis in rubber grommets. By contrast, the two output transistors are mounted in heatsink flags which are screwed to the chassis.

The various connections are made using a combination of tagstrips and point-to-point wiring. The components used were something of a mixed bag – the IF coils are the slim rectangular Philips types, the capacitors are a mix of UCC and Philips electrolytics and the bypasses are AEE "microcaps", mostly the brown variety. The low-power transistors are all in the familiar black-painted "bullet" outline, so it's safe to assume they're from Philips. The same goes for the demodulator diode (D1).

A large tuning-gang with identi-

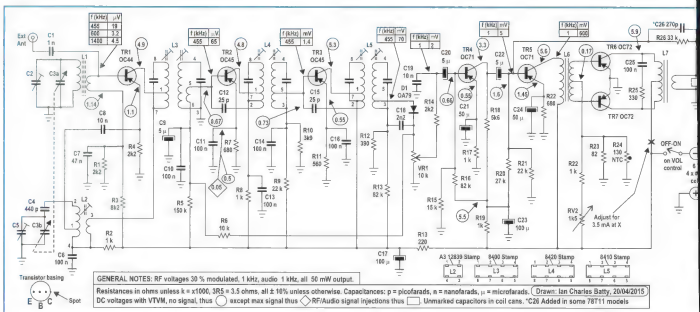


Fig.1: the circuit is a fairly-conventional 7-transistor superhet design. TR1 is the converter stage, TR2 & TR3 are IF amplifiers, D1 is the demodulator and TR4-TR7 the audio amplifier stage.

cal sections is mounted at one end of the chassis, adjacent to a 5-inch Rola loudspeaker. As with the audio transformers used in the set, it's about the same size as those used in various valve portables of the era. In fact, judging by the parts used, it appears that the application circuits in Philips' "Miniwatt" handbook of 1957 were used as a guide by Stromberg-Carlson's designers.

The bias adjustment for the output stage is a real oddity. It's a slider-type wirewound resistor with a 10W rating and I suspect that the principal criterion for its use was availability rather than its power rating.

A date stamp on the audio driver transformer (9 May 1958) places this particular set near the beginning of the production run.

Circuit description

The "Transistor Seven", as the set was called, was issued in two versions: the 78T11 portable and the very similar 79T11 with switching for an external car radio aerial. This article describes the 78T11 and any component differences between the two are noted in the text.

Both the 78T11 and 79T11 use OC-series transistors throughout, beginning with an OC44 converter (TR1) – see Fig.1. This converter uses collector-emitter feedback to give minimal local oscillator radiation. A 440pF padder capacitor (490pF in the 79T11) across one section of the gang sets the local oscillator range to the standard 990-2060kHz range for broadcast-band reception.

Since the OC44 is configured as a self-excited converter, no AGC is applied. The output from the converter feeds the 1st IF transformer (L3) via a double-tuned IF transformer with tapped primary and secondary windings.

The 78T11 has a permanently-connected aerial socket which goes directly to the base of TR1. By contrast, the 79T11, which is purpose-built as a car/portable set, has an antenna changeover switch. This selects either a fully-matched antenna coil that's coupled to a car radio antenna (for car use) or an internal ferrite rod for portable use.

Each antenna coil (car and portable) has its own trimmer. The car antenna coil uses capacitive and inductive coupling to give maximum signal pick-up, necessary because of the short antenna that car sets usually connect to.

The first IF amplifier's OC45 (TR2) has AGC applied via its base bias network. In addition, neutralisation is ap-

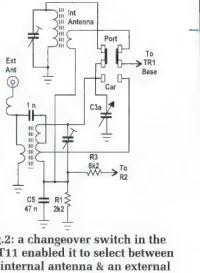


Fig.2: a changeover switch in the 79T11 enabled it to select between its internal antenna & an external car radio antenna. This circuit replaced the shaded area in Fig.1.

The controls for the Stromberg-Carlson 78T11/79T11 are mounted on the top of the case, with the volume control at left and the tuning control at right. The tuning wheel's rim is driven via a rubber grommet attached to a small knob.

plied from a tap on the primary of the second IF transformer (the 79T11 takes its neutralisation from the second IF transformer's secondary). Even though the 78T11's first IF has a double-tuned primary and secondary, the first IF transistor (TR2) gets its signal from a tertiary winding on this IF transformer (L3). By contrast, the 79T11 uses the more conventional tapping on the first IF's secondary.

As shown on Fig.1, the 78T11's second IF transformer (L4) is double-tuned, with tapped primary and secondary windings. Once again, the 79T11 uses a different arrangement – its second IF uses a tuned and tapped primary, while its secondary is untuned and untapped.

IF amplifier TR3 operates with fixed bias and has neutralisation applied from a tap on the third IF transformer's primary (the 79T11 takes its neutralisation from the third IF's secondary). This third IF transformer (L5) is double-tuned and has tapped primary and secondary windings. The 79T11 differs yet again in that its secondary is un-tuned and untapped.

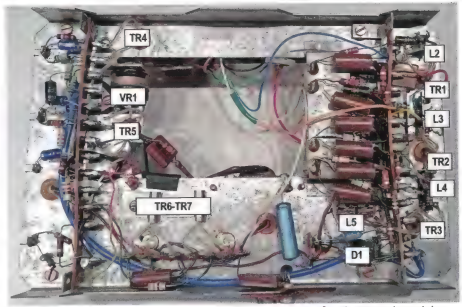
Diode D1 demodulates the IF signal and also supplies the AGC. As shown, the AGC line feeds back to TR2's base via R6 and the tertiary winding in L3. TR2's bias is set by R12 & R13 and this also applies a small forward bias voltage to D1, thereby increasing its sensitivity.

The demodulated output from D1 is positive-going and the AGC action results in strong signals reducing the bias on TR2. This in turn reduces its gain and keeps the audio output fairly constant with varying signal strengths.

Audio output stage

The audio section is a conventional 4-transistor design based on preamplifier stage TR4, driver stage TR5 and Class B push-pull output stage TR6 & TR7. As shown, the drive from TR5 is coupled to the output stage via centre-tapped transformer L6 which acts as a phase splitter. The push-pull output stage then drives the loudspeaker via centre-tapped transformer L7.

Feedback is applied from the speaker back to the base of driver stage TR5 via R26 & C26 in parallel. In common with other Australian designs, the output stage bias is adjustable, in this case via trimpot RV2, and is temperature-compensated using R24, a 130Ω thermistor.



The circuit is built on a metal chassis, with tagstrips and point-to-point wiring. Transistors TR1-TR5 are mounted through the chassis in rubber grommets, while output transistors TR6 & TR7 are secured in place using flag heatsinks.

One unusual design aspect is that the output stage transistors (TR6 & TR7) have no emitter resistor(s). It's more common to see either two low-value emitter resistors of about 10Ω or a single shared emitter resistor of similar value. These normally help reduce output stage distortion and provide some extra temperature compensation but have been omitted from this design.

Finally, it's worth noting that subsequent releases (designated the 78T12, 70T11 and Wayfarer) used alloy-diffused OC170/169s in the RF/IF stages and OC74s in the output. In addition, the Wayfarer featured an inbuilt Hoffman solar battery and could also be slipped into a cradle for use as a car radio.

The electrolytic capacitors were all replaced, as was transistor TR2 which had excessive collector-base leakage.

Restoration

The first job in restoring the set involved a good clean-up. As with other sets of the era, the Stromberg 78T11 uses a leatherette case and its heavy texture had me reaching for soap and a toothbrush.

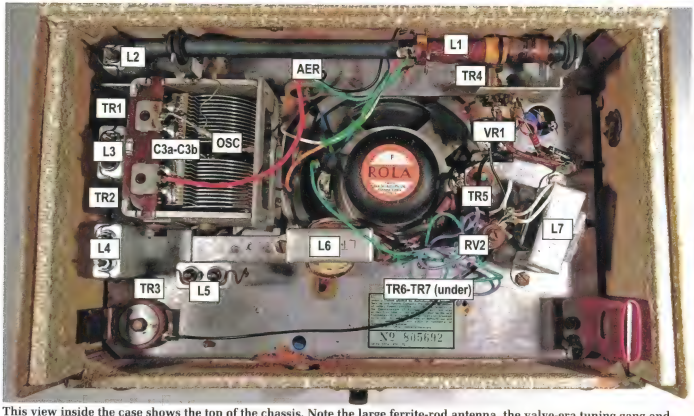
After some patient effort, it cleaned up quite nicely. The "Transistor 7" badge on the top of the case had corroded at the edges but was left in place. This set is nearly 60 years old, after all.

The knobs all had small edge cracks around their skirts but rather than use a windscreen repair kit to make the cracks invisible, they were again left as they were; it's all part of the set's patina and commensurate with its age.

Testing

Having cleaned the set up, it was time to see if it worked. It's always a good idea to increase the voltage slowly while monitoring the current when testing transistor sets, just as it is with valve sets. Admittedly, transistor sets are less likely to have disastrously leaky electrolytics (the reason for caution in valve sets) but it's possible for output stage faults to cause massive current flow, resulting in further damage.

In this set, increasing the supply voltage slowly up to 6V resulted in a current drain of around 10mA. Any-



This view inside the case shows the top of the chassis. Note the large ferrite-rod antenna, the valve-era tuning gang and the 5-inch (127mm) loudspeaker. All the parts are readily accessible and only the electrolytic capacitors and a single transistor required replacement. A few alignment adjustments then restored the set to full working order.

where from around 5-15mA is pretty normal, so this indicated that the output stage was probably OK. However, there was no sound from the set apart from a brief "click" when the power supply was connected.

It was time for some troubleshooting. First, I injected a 455kHz signal from a signal generator into the aerial coil but there was still no audio output. I then cranked the signal generator up to some tens of millivolts (mV) and this time got a barely audible, distorted tone.

This indicated that the front end could be OK, so I tried injecting an audio signal into the volume control (VR1). I found that I needed to feed in over 100mV to get anything through the audio stage and it was the same when I fed the signal directly to TR4's base.

Replacing coupling capacitors C20 & C22, along with new bypass capacitors for C21 & C24, solved the problem, with the required signal level for an audible output now reduced to just 5mV. What's more I could now receive ABC Melbourne (774kHz) and Radio National (621kHz) at reasonable volume.

Injecting 455kHz into the aerial terminal then allowed me to tweak up the IF strip. I also adjusted the oscillator coil for maximum sensitivity and this resulted in a sensitivity of just a few microvolts at the aerial terminal.

Unfortunately, when I cranked up the signal, the output first increased but then flattened off and decreased! I checked TR2's emitter voltage and found that it fell from around 0.8V to only about 0.6V at full signal, whereas it should have fallen to almost 0V due to AGC action.

The culprit turned out to be excessive collector-base leakage in TR2. This was acting as an internal bias circuit, preventing the AGC circuit from correctly reducing the bias for strong signals. Replacing TR2 fixed that problem and both TR1 & TR3 were also checked to make sure they were OK.

Leakage is a known problem with germanium transistors. A transistor may work just fine in some circuits but can cause problems in low-level gain-controlled stages and output stages. Alternatively, they can fail catastrophically due to excessive leakage current. If you work on old equipment (especially using germanium devices), a leakage tester is vital to check that the transistors are OK.

Capacitor replacement

Some (if not most) restorers regard all old capacitors as suspect – paper types will be probably leaky, while electrolytics may also be leaky and/or of low value. In their view, a complete "recap" eliminates the possibility of faulty capacitors and makes restoration more straightforward.

I generally prefer to take a more conservative approach but given that I'd found all four audio-stage electrolytics to be faulty, I went ahead and replaced the remaining electrolytics as well.

This set also had an annoying low-

Removing The Knobs

As with the Bush TR82's tuning knob, the 78T11's tuning and volume knobs must be removed carefully. In this case, I was able to remove the knobs by applying steady finger pressure but you may prefer to use several lengths of string under the knobs to spread the load. The Vintage Radio column in the September 2013 issue shows the method.

Metallic levers (such as screwdrivers) are a recipe for disaster. Don't even think of using them.

How Far Do You Go With Restoration?

Old valve radios present many well-known problems for restorers. These include leaky or shorted capacitors, high or open-circuit resistors, dead or low-emission valves, open-circuit transformer windings, battery corrosion and noisy volume control pots. My own experience with all kinds of radios shows that while a set may appear to "work", a thorough examination often reveals defects that detract from its intended performance.

Now add a novel type of deterioration for early transistor sets: leakage in (mostly) germanium transistors and capacitors that allow a set to work "pretty well" but not up to its original specification. Both the 78T11 and the Pye Jetliner that I recently restored suffered AGC faults due to leakage (in a transistor and a capacitor, respectively).

Often, a restorer won't bother to troubleshoot further if it works OK on local stations. Indeed, it's up to the individual to decide just how far to go in the restoration process and whether they want the set to perform to its maximum potential. Some things to consider include: no-station current drain, distortion and current drain at full output, sensitivity, freedom from oscillation (or "howling"), the AGC action and the audio frequency response.

level "wip-wip-wip" oscillation on all volume settings. An oscilloscope check showed a trace much like the parasitic oscillation that's sometimes seen in high-gain audio and HF/VHF RF power amplifiers. The culprit was C17, the main audio bypass capacitor. A faulty AGC bypass capacitor (C9 in this set) can cause audio oscillation. It certainly did on the TR-1 set that I restored (see Silicon Chip, September 2012).

Performance

Describing a set as being "very good for its age" can be a cheap shot but this set really is a good performer. In fact, it matches the excellent Philips 198 – it's pretty much the same design but with better audio response according to my test results.

Getting down to actual figures, at maximum gain, it needed field strengths of 30µV/m and 35µV/m for 50mW output at 600kHz and 1400kHz respectively – but with corresponding signal-to-noise (S/N) ratios of just 7dB and 5dB.

For a 20dB S/N ratio, the sensitivity at 600kHz is about 100µV/m and at 1400kHz about 150µV/m. This set's AGC action has a very early onset, so delayed AGC would have given an even better figure than my test results.

As for selectivity, this measured ±1.5kHz at -3dB and ±11.5kHz at -60dB. The AGC held the output to a 6dB increase for a signal increase of 34dB and the set needed some 40mV/m in order to go into overload.

Distortion measurements

The audio stage also performs impressively, with a frequency response from the volume pot onwards of about 45Hz to 7kHz (-3dB points). By contrast, the response from the aerial terminal to the output is about 40Hz to 2kHz. The distortion (THD) was well-controlled: 1.7% at 10mW, 3.5% at 50mW and 5.2% at the onset of clipping (160mW). At full output (about 200mW), the THD rises to some 13%.

Supply voltage

The supply voltage for the set is nominally 6V (4 x 1.5V cells). When the supply is down to just 3V, the maximum output is around 40mW for a THD of 5%, falling to about 2.6% at 10mW.

All in all, the Stromberg-Carlson 78T11 is a solid performer and is an important example of early Australian transistor radio design. If you have one, get it out and restore it to full working order.

Further Reading

For schematics, see Kevin Chant's website:
www.kevinchant.com/uploads/7/1/0/8/71082231/78t11.pdf
www.kevinchant.com/uploads/7/1/0/8/71082231/79t11.pdf

For Stromberg-Carlson's Australian history:
www.radiomuseum.org/dsp_hersteller_detail.cfm?company_id=7578

Many references also exist for the US parent. Among them, see:
www.radiomuseum.org/dsp_hersteller_detail.cfm?company_id=751 SC

Ultra-LD Mk.4 Power Amplifier Preview . . . continued from p82

negative output excursions via the other pair of output transistors are shown in blue and cyan.

During positive output excursions, current flows from the positive supply input connector to Q10 and Q11 (the NPN output transistors) and then to the output filter (L1, etc) and the positive speaker lead, via paths that overlap almost completely. Return current from the black speaker lead to the power supply ground connection completes the loop. The part of the loop where the current paths diverge is the section around the RLC output filter and this is difficult to avoid.

The negative path through Q12 and Q13 is shorter but otherwise similar; again, the only real loop area is through the output filter. In fact, since the positive and negative paths converge at the top end of L1, the current in this section of the loop is not half-wave rectified (ie, it is effectively just the output current) and so it's far less of an issue in terms of radiation and distortion as it lacks the sharp transitions of the Class-B current.

Note that the 0.1Ω emitter resistors for the power transistors are 3W SMD types mounted directly under the respective positive and negative supply fuses. Besides being far more compact than the previously specified 5W wirewound resistors, the SMD types are non-inductive and their positioning gives much better field cancellation.

L1 will generate its own magnetic field due to this current flow and this is why its winding direction and the number of turns are quite critical; if orientated correctly, the field generated by the output current flowing through L1 will at least partially cancel with the field generated by current flowing through the loop formed by the PCB tracks that was explained above.

This does not consider current supplied to the output from any of the on-board bypass capacitors, however their paths have been designed to be relatively tight loops as well.

Acknowledgement

Thanks to reader Alan Wilson for suggesting many of the part substitutions that we are using in the new design and prompting us to investigate some of the other changes we were considering for our next amplifier. SC

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PIC32MX170F256D-501/PT 44-pin Micromite Mk2 (Now with Mk2 Firmware at no extra cost)

PIC32MM250F128B-I/SP GPS Tracker (Nov13) Micromite ASCII Video Terminal (Jul14)

PIC32MX470F512H-I/PT Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14), Digital Effects Unit (Oct14)

dsPIC33FJ128GP802-I/SP Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicaliser (Nov12)

dsPIC33FJ64MC802-E/P Induction Motor Speed Controller (revised) (Aug13)

dsPIC33FJ128GP306-I/PT CLASSIC DAC (Feb-May 13)

ATTiny861 VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)

ATTiny2313 Remote-Controlled Timer (Aug10)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, SHORT-FORM KITS, ETC

P&P – $10 Per order#

NEW: MINI USB SWITCHMODE REGULATOR all SMD components *(July 15)* **$10.00**

BAD VIBES INFRASOUND SNOOPER - TDA1543 16-bit Stereo DAC IC *(Jun 15)* **$2.50**

BALANCED INPUT ATTENUATOR - all SMD components inc.12 NE5532D ICs, 8 SMD diodes, SMD caps, polypropylene caps plus all 0.1% resistors (SMD & through-hole) *(May 15)* **$65.00**

APPLIANCE INSULATION TESTER - 600V logic-level Mosfet. 5 x HV resistors: *(Apr15)* **$10.00**

ISOLATED HIGH VOLTAGE PROBE - Hard-to-get parts pack: all ICs, 1N5711 diodes, LED, high-voltage capacitors & resistors: *(Jan15)* **$40.00**

CDI – Hard-to-get parts pack: Transformer components (excluding wire), all ICs, Mosfets, UF4007 diodes, 1µF X2 capacitor: *(Dec 14)* **$40.00**

CURRAWONG AMPLIFIER Hard-to-get parts pack: LM1084IT-ADJ, KCS5603D, 3 x STX0560, 5 x blue 3mm LEDs, 5 x 39µF 400V low profile capacitors *(Dec 14)* **$50.00**

ONE-CHIP AMPLIFIER - All SMD parts *(Nov 14)* **$15.00**

DIGITAL EFFECTS UNIT WM8371 DAC IC & SMD Capacitors *[Same components also suit Stereo Echo & Reverb, Sept14 & Dual Channel Audio Delay Nov 14]* *(Oct14)* **$25.00**

AD8038ARZ Video Amplifier ICs (SMD) For Active Differential Probe (Pack of 3) *(Sept 14)* **$12.50**

44-PIN MICROMITE Complete kit inc PCB, micro etc *(Aug14)* **$35.00**

MAINS FAN SPEED CONTROLLER - ADT11N60L 600V Mosfet *(May14)* **$5.00**

RGB LED STRIP DRIVER - all SMD parts and 8SD150N03 Mosfets, does not include micro (see above) nor parts listed as "optional" *(May14)* **$20.00**

HYBRID BENCH SUPPLY- all SMD parts, 3 x BCM856DS & L2/L3 *(May 14)* **$45.00**

USB/RS232C ADAPTOR MCP2200 USB/Serial converter IC *(Apr14)* **$7.50**

NICAD/NIMH BURP CHARGER - all SMD parts, 2 x BD4911 P-channel logic Mosfet & 1 IPP230N06L3 N-channel logic Mosfet *(Mar14)* **$7.50**

10A 230V AC MOTOR SPEED CONTROLLER 40A IGBT, 30A Fast Recovery Diode, IR2125 Driver and NTC Thermistor *(Feb14)* **$45.00**

GPS Tracker MCP16301 SMD regulator IC and 15µH inductor *(Nov13)* **$5.00**

SMD parts for SiDRADIO Same as LF-HF Upconverter parts but includes 5V relay and BF998 dual-gate Mosfet. *(Oct13)* **$20.00**

RF Probe All SMD parts *(Aug13)* **$5.00**

LF-HF Up-converter Omron G5V-1 5V SPDT 5V relay *(Jun13)* **$2.00**

"LUMP IN COAX" MINI MIXER SMD parts kit: *(Jun13)* **$20.00**
Includes: 2 x OPA4348AIO. 1 x BQ2057CSN, 2 x DMP2215L, 1 x BAT54S, 1 x 0.22Ω shunt

LF-HF UP-CONVERTER SMD parts kit: *(Jun13)* **$15.00**
Includes: FXO-HC536R-125 and SA612AD and all SMD passive components

CLASSIC DAC Semi kit – Includes three hard-to-get SMD ICs: *(Feb-May13)* **$45.00**
CS8416-CZZ, CS4398-CZZ and PLL1708DBQ plus an accurate 27MHz crystal and ten 3mm blue LEDs with diffused lenses

ISL9V5036P3 IGBT Used in high energy ignition and Jacob's Ladder *(Nov/Dec12, Feb13)* **$10.00**

2.5GHz Frequency Counter *(Dec12/Jan13)*
LED Kit: 3 x 4-digit blue LED displays **$15.00**
MMC & Choke Kit: ERA-2SM+ Wideband MMC and ADCH-80+ Wideband Choke **$15.00**

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*All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable. # P&P prices are within Australia. Oseas? Please email for a quote

PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB only – *not a full kit*. If you want a kit, contact the kit suppliers advertising in this issue. For more unusual projects where kits are not available, some have specialised components available – see the list opposite.

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
PROJECTOR SPEED CONTROLLER	APRIL 2011	13104111	$10.00
SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00
100W DC-DC CONVERTER	MAY 2011	11105111	$15.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00
20A 12/24V DC MOTOR SPEED CONTROLLER MK2	JUNE 2011	11106111	$20.00
USB STEREO RECORD/PLAYBACK	JUNE 2011	07106111	$20.00
VERSATIMER/SWITCH	JUNE 2011	19106111	$25.00
USB BREAKOUT BOX	JUNE 2011	14106111	$10.00
ULTRA-LD MK3 200W AMP MODULE	JULY 2011	01107111	$25.00
PORTABLE LIGHTNING DETECTOR	JULY 2011	04107111	$20.00
RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per set
VOX	JULY 2011	01207111	$20.00
ELECTRONIC STETHOSCOPE	AUG 2011	01108111	$10.00
DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$10.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$20.00
ULTRA-LD MK2 AMPLIFIER UPGRADE	SEP 2011	01209111	$5.00
ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	$20.00
GPS FREQUENCY REFERENCE (IMPROVED)	SEP 2011	04103073	$30.00
HEARING LOOP RECEIVER/CHECK COUPLER	SEP 2011	01209101	$10.00
DIGITAL LIGHTING CONTROLLER LED SLAVE	OCT 2011	16110111	$30.00
USB MIDIMATE	OCT 2011	23110111	$25.00
QUIZZICAL QUIZ GAME	OCT 2011	08110111	$25.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$20.00
ULTRA-LD MK3 INPUT SWITCHING MODULE	NOV 2011	01111112	$20.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$25.00
DIGITAL AUDIO DELAY Front & Rear Panels	DEC 2011	01212112/3	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101212	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08106121	$10.00
CAPACITANCE METER	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110122	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to +35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSAR MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp [Sept11])	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS	DEC 2013	01111131-3	$35.00/set
(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])			
LED Party Strobe (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
Bass Extender Mk2	JAN 2014	01112131	$15.00
12/1 Pulser Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$12.50
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	16105141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE eSOI VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141a/b	$15.00
VALVE SOUND SIMULATOR PCB	AUG 2014	01106141	$15.00
VALVE SOUND SIMULATOR FRONT PANEL (BLUE)	AUG 2014	01106142	$10.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
4A-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THEREMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/SET
MINI-D AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111142	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	-	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$15.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$15.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$20.00
4-OUT/1-UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00
SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00
BAD VIBES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION + PRE-CHAMPION	JUNE 2015	01109121/2	$7.50

NEW THIS MONTH

DRIVEWAY MONITOR TRANSMITTER PCB	JULY 2015	15105151	$10.00
DRIVEWAY MONITOR RECEIVER PCB	JULY 2015	15105152	$5.00
MINI USB SWITCHMODE REGULATOR	JULY 2015	18107151	$2.50

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Sidereal clock with GPS accuracy

I am interested in astronomy and would like to design a sidereal clock. To keep it accurate, I was thinking of using a GPS module that has a 1 PPS output as the main clock. I am not sure whether this output would need to be buffered or needs to be inverted before going to the counters. I know you can use a crystal-based counter but you would have to periodically trim the crystal.

I am thinking of using a CMOS IC for the clock circuitry, with a 6-digit 24-hour readout and blue 7-segment displays. So nothing fancy here; just a 1Hz pulse running the counters and display ICs. The problem is that a sidereal second is not 1Hz but is 1.002738Hz. I have a circuit to do this but it is not my design and I am hesitant to use it. How would you convert 1Hz to 1.002738Hz? Any suggestions?

I envision the clock having two displays, the first being Local Time and the second being Sidereal Time. I hope you can help. (R.M., Melville, WA).

● In fact, a sidereal second is equivalent to 1.002 737 909 350 795Hz and any circuit to produce this over time will be at best an approximation and will not able to compensate for long term variations due to nutation.

We have produced several circuits for sidereal time:
(1) Microprocessor-Based Sidereal Clock, in August 1993;
(2) Circuit Notebook: Add-on Circuit For A Sidereal Clock, June 1993; and
(3) 24-Hour Sidereal Clock For Astronomers, March 1993.

Probably the most relevant to you is the March 1993 circuit which used a 32kHz crystal and a divider based on CMOS 4527 rate multipliers to produce a little over 65Hz to drive a clock chip and LCD display.

If you wanted to use the 1PPS signal from a GPS module, you would need to use a microprocessor to produce the correct multiplier and then add the facility to toggle between GPS and sidereal time. Our 6-Digit GPS clock from the May & June 2009 issues could possibly have its software modified to provide these two functions.

Hum problem with Bass Extender

I built the Bass Extender (SILICON CHIP, January 2014) into the Tiny Tim Amplifier (October & December 2013, January 2014) and put the lot into a beautiful 19-inch case from Altronics, so there is plenty of space between boards. I have inserted the Bass Extender between the preamp and power amplifier by cutting the relevant track between the 220µF capacitor and the 180kΩ resistor.

To power the Bass Extender, I picked up 15VAC from the toroidal transformer which in retrospect I think may have been a bad call. There is now hum that is not adjustable by the Tiny Tim's volume control. Strangely however, the hum is louder when the Bass Extender volume is turned down and harder to hear when up full.

It is in both channels and not really acceptable. I think it is from the AC supply because when I touch or move the 15VAC wires between the transformer and the Bass Extender board, the hum varies in intensity, sometimes disappearing.

So is it bad to have AC current inside the amplifier case in general for this reason and should I have opted for the DC version of the Bass Extender? If so, would the rectified 20V output from the transformer do the trick (ie, it is unregulated)? Otherwise I could

Rev Counter For Induction Motor Speed Controller

I built the Speed Controller for Induction Motors and use it to drive my milling machine equipped with a 3-phase motor. It works well and has saved me heaps of money because I did not need to install 3-phase power. The motor has two windings, 1450 RPM and 700 RPM, selectable via a switch on the mill.

I would like to attach a rev counter to the milling head, so I could make use of the variable speed function and still get the ratio of RPM and cutter diameter right. Now I use full motor speed and select gears to do this. Is there a simple RPM counter (ranging from zero up to about 2000 RPM) you could suggest or even produce a kit? Hall effect or magnet pick-up would work.

Many constructors of speed controllers might be interested to know the speed of the motors. Both Jaycar and Altronics seem not to have something suitable, either as a kit or module. Please help. (H. M., via email).

● Have a look at our LED Strobe & Tachometer, as featured in the August & September 2008 issues. You can see free 2-page reviews of these articles at: http://siliconchip.com.au/Issue/2008/August/LED+Strobe+%2526+Contactless+Tachometer and http://siliconchip.com.au/Issue/2008/September/LED+Strobe+%2526+Contactless+Tachometer%2C+Pt.2 The project is still available as a kit from Altronics (Cat K2510).

Alternatively, if you don't mind doing some mental calculations, you could simply measure the output frequency of the Speed Controller and then do the sums (allowing for slip). We showed a simple method of measuring output frequency in Circuit Notebook, September 2014 – see www.siliconchip.com.au/Issue/2014/September/Measuring+the+frequency+output+of+the+Induction+Motor+Speed+Controller?

try running shielded cable to power the Bass Extender. (G. M., via email).

● If you have AC wiring running close to sensitive circuitry then there is the possibility of hum pick-up. There are a number of things you can do to reduce this:

(1) Make sure that the AC wires run as close to each other as possible. One good way to do this is to twist them together or you could use figure-8 cable or heatshrink tubing.

(2) Route the AC wires away from any high-impedance signal circuitry such as the Bass Extender.

(3) Add shielding. Often, placing a blank PCB immediately below the signal PCB with its copper side facing away (to avoid short circuits), then connecting the copper to ground via a length of wire, will substantially reduce hum pick-up.

(4) Put the Bass Extender inside an earthed metal box and then put this inside the main case, to provide extra shielding.

If none of that works, you could reconfigure the Bass Extender to run off DC, then rectify and filter the AC off-board (with a small bridge rectifier and suitable filter capacitor(s)). Then you only need to run DC to the Bass Extender board. But given that our prototype Bass Extender was run off a 15VAC plugpack with no noticeable hum, it should be possible to run AC wiring up to the board and get acceptable performance.

Questions About Car Electronics

I am a member of a 300ZX car forum and a current issue involves an ECU which sends an RPM signal to two other control units. One controls the rear wheel hydraulic steering and the other control unit is the automatic transmission unit.

When the steering control unit (Super HiCAS control unit) is disconnected, the RPM signal does not display on an after-market digital tachometer; reconnect the Super HiCAS unit and the display works. The Transmission Control unit seems to work but not the digital tacho.

I was thinking that the HICAS unit is loading the engine ECU and varying the signal so that the digital tacho cannot resolve the modified signal. There are no schematics for the units mentioned. Any thoughts about what may be happening and how to rectify the situation? (M. S., via email).

● Many signals from an ECU such as the RPM signal are from an open-collector output. This means that there is a transistor output that can drive voltage to 0V but it requires a pull-up resistor to have the signal rise to (usually a 5V level) when the transistor is off.

The reason for using an open collector-output is to level shift the signal, if required, and also for the ECU to recognise when the signal output is connected to another unit such as the steering control unit. If the signal remains at 0V, that would mean that the pull-up is not connected. Since the pull-up resistor is in the steering control unit, it allows the ECU to know when the control unit is connected. The ECU may produce an error code if there is a detected disconnection.

Similarly, many sensors such as reluctors used in speed sensors on the wheels and gearbox produce an AC output. Often one side of the reluctor coil is connected to a 2.5V supply within the ECU. This allows the reluctor signal to deliver a signal voltage that varies about a 2.5V supply (that's half the 5V ECU supply). The ECU is also then able to detect a disconnected or faulty sensor simply by monitoring the sensor DC voltage on each side of the reluctor coil. If either connection is not at 2.5V, then the sensor is disconnected.

So if by disconnecting the steering control unit, the tachometer does not work, there could be a missing pull-up resistor that would be required to have the correct signal.

The RPM signal from the ECU should be observed using an oscilloscope when the steering control unit is connected and again when it is disconnected to see how the RPM signal changes. Possibly it will need a pull-up resistor (eg, 10kΩ) to a set voltage. The voltage that the signal is pulled up to would need to be checked on the oscilloscope and a suitable voltage provided to duplicate this for the pull-up resistor.

Panel theft alarm for MPPT charge controller

I have built the MPPT Solar Charge Controller (SILICON CHIP, February 2011 & March 2012) and I am using it to power a security alarm system for a remote shed. The standby alarm current is only 55mA so a low-dropout 12V linear regulator is OK although I could have used a buck-boost 12V regulator to allow the battery voltage to go down to 10.5V.

On the MPPT Solar Controller there is an output that indicates when the battery voltage is high or low. You may want to do another article describing how to modify this output to instead indicate that the PV panel has been covered or stolen.

This line could then be connected to one of the alarm system zone inputs. There would have to be a timer that is longer than night-time to stop false triggering the alarm. Changes could be as simple as using different firmware with no circuit changes; adding links or whatever to the circuit board with a firmware change.

Another firmware improvement could be to extend the time for Absorption mode when the PV panel voltage does not give an Absorption voltage of 14.4V, to ensure that Absorption is completed if voltage is low. The article indicates it is fixed at one hour. Am I correct with this?

By the way, the voltage graph for float mode in Fig.4 looks to be too high. It is shown as being the same voltage as the Bulk voltage. (R. W., via email).

● With regard to having an output to signal whether the solar panel is inoperative through theft, covering or other fault, the TP4 output can be used for this as it goes to 5V when the battery voltage drops below 11.5V. That indicates that the battery is not charged. The output covers more scenarios than just whether the solar panel is working. It could be that the battery is faulty and not holding charge.

There does not seem to be any other easy way to detect whether the solar panel is inoperative due to being covered or through theft. That's because there could be a series of very dull cloudy days that produce the same effect as an inoperative/stolen or covered solar panel.

The one-hour absorption is recommended by SLA manufacturers. Ab-

Inductive Pick-Up Needed For LED Tacho

I built the LED Strobe & Tacho project from the August & September 2008 issues some ago and have found it to be very handy both in my profession as an electric motor & generator rewinder and for my hobbies. Just recently, I have had a need for a tachometer to monitor the speed of the engine in my car after replacing the automatic gearbox with a 5-speed manual gearbox.

This entailed changing the ECU from the manual donor car. It seems that the instrumentation/tacho units in the manual and auto versions are slightly different as the original tacho now reads high by an estimated 300-400 RPM. By ear, the engine speed does not seem to have altered but I would like to be sure. This is where the LED Strobe comes in to the picture.

I can see that the when the original tacho in the vehicle is reading 1100 RPM, the strobe indicates an idle speed of 720 RPM, which is correct. However, what I really need is an inductive pick-up to feed the trigger input of the LED Strobe & Tacho, ideally taken inductively from one of the spark plug leads so I can monitor the speed as I drive and at higher engine speeds where it is not practical to shine the strobe onto the harmonic balancer. Would you be able to supply a suitable trigger circuit to achieve this?

My next question relates to the same scenario. The speedo is now inaccurate and is reading 10km/h fast, ie, GPS shows I am travelling at 100km/h but the speedo shows 110km/h. The donor vehicle is the same sedan model as my car (a 2004 Magna TL wagon) and built the month before, so they are almost the same age.

Both cars have the same size wheels and tyres so the issue is not there. Could you please tell me if the latest Speedo Corrector (SILICON CHIP, September 2013) project would be suitable for the Magna and where the speedo signal might be intercepted? (P. C., via email).

● You should be able to trigger the LED Strobe & Tachometer using the ignition coil primary voltage that's switched on and off for coil firing. The signal would be applied via the 3.5mm jack socket but with the 2.2Ω and 10kΩ resistors connecting to +5V removed and the 1kΩ resistor connecting to pin 6 of IC1 changed to 10kΩ 1W.

The 1nF capacitor between pin 6 and ground should be changed to 220nF. Also a 5.6V 1W zener diode should be connected between pin 6 and ground, with the cathode end to pin 6. The 220nF capacitor may need to be increased in value should the readings be erratic or reduced, if the upper RPM readings drop to 0.

The Speedo Corrector should be suitable to modify the speedo readings. However, be aware that under Australian Design Rules, speedos are required to show an equal or higher speed than actual, so a 110km/h reading for an actual 100km/h is only a little more than a typical indication.

You will probably find that at 50km/h or 60km/h, the actual and indicated speeds are much closer. If there is still an error, then you could consider using the Speedo Corrector.

sorption will occur at 14.4V since this is the threshold that the bulk charge must reach before the absorption phase begins. If the bulk charge does not reach 14.4V, then absorption will not begin; bulk charge will continue until 14.4V is reached. So the hour of absorption once 14.4V is reached is OK.

Fig.3 shows the float charge being lower than the bulk end point and absorption voltage and that is what is expected. However, after equalisation as shown in Fig.4, it can take considerable time for the battery voltage to fall back to lower than the cut-off voltage and then to its normal lower float voltage.

While the diagram is not meant to show specific voltage it should have shown the float voltage dropping a little lower than the cut-off voltage over time as you point out.

Converting balanced output to unbalanced

I am interested in building the Balanced/Unbalanced Converter For Audio Work, as featured in your June 2008 issue. I have a preamplifier with XLR balanced outputs only and want to connect it to my stereo power amplifier which has unbalanced RCA inputs. So I have some questions regarding this converter.

Looking at the PCB layout and schematic, I do not see a left and right balanced input or left and right unbalanced output. So is this only for a single channel and do I need two boards for stereo balanced to unbalanced conversion? Your help would be greatly appreciated. (P. O., via email).

● The balanced to unbalanced converter is only single channel. If you want a stereo balanced to unbalanced converter you need to build two. Each PCB comprises a balanced to unbalanced section and an unbalanced to balanced section. For your application, the parts for the unbalanced in to balanced output can be omitted from the PCB.

Connection from your preamplifier balanced output would be to the balanced input on the balanced to unbalanced converter. The unbalanced output goes to the power amplifier. Make sure the signal and ground connections are correct. The balanced input uses the 0V input for the shield on the balanced signal wires. The in-phase wire is for the "+" input; out-of-phase to the "-" input.

Positive earth ignition system

Is it possible to use the High Energy Ignition System (SILICON CHIP, November & December 2012) in a positive earth car? I have an Austin Healey Sprite Mark 1 that is positive earthed. I could wire the case to positive internally. (M. H., via email).

● We published a positive earth modification for our earlier High Energy Ignition (HEI) in November 1997, in the Ask SILICON CHIP pages (page 90).

This described the basic method. You would need to wire the ignition coil (and ballast resistor if used) between the positive and IGBT collector as shown in the November and December 2012 circuit but with the metal case of the HEI connected to the vehicle chassis (positive) instead

of the negative. That means the negative supply for the HEI would need to be wired separately to the negative supply of the vehicle.

The other problem involves the trigger. If you are using points (ie, as originally equipped), they will have to be isolated from from the positive chassis using a transistor mica washer and insulating bush (or similar high heat-rated parts), so that the points can be rewired to switch to the negative supply. Alternatively, you could use the additional input transistor circuit shown in the November 1997 issue mentioned above to invert the points sense.

With the 2012 HEI you do not need to invert the sense of the points signal with a transistor inverter, since there is a link option to do that already.

If using a Hall Effect trigger or optical trigger or reluctor, these would need to be connected with the supply for this referenced to the negative supply. These invariably are intended for negative chassis vehicles. So it may be necessary to isolate the trigger unit from the positive chassis if the trigger unit obtains its negative supply via a connection to the chassis.

Hall Effect and optical pick-ups often have the three separate wires (positive, negative and signal) brought out and are isolated from the chassis connection. Some reluctor units will only have one wire, with the chassis connection tying the other coil end of the reluctor trigger to the negative supply. This would need to be isolated and the reluctor case tied to the negative supply separately.

Kit for an irrigation controller wanted

Have you ever published a kit for an irrigation controller? These controllers are sold for the domestic market and for industrial use. They switch on/off solenoid controlled water valves which irrigate garden beds etc. I think the standard irrigation valve solenoid is 24V.

I have an irrigation system in the backyard with five separate stations (ie, five valves) and the controller needs replacement. The one installed is a Holman which is sold by Bunnings along with other brands and a decent unit costs about $150-200.

They generally require programming at the site of the box (in my case an inside filter box) and this is the hassle. The controller is mains-powered and a low voltage cable (like an Ethernet or telephone wire) then runs from the controller to the solenoids. It would be much easier to program the controller from a web interface.

There is a vendor in USA who produces such a device – see http://rayshobby.net/

It's nice because it is expandable and if fitted into a waterproof housing, it could be mounted externally. It could also be used to switch devices like low-voltage lighting or even mains-powered devices if coupled correctly. And it can be programmed from the desktop web interface (ie, via an Ethernet/powerline connection to the home network or WiFi).

Sometimes the small LCD screen on a device like the Holman controller is difficult to make sense of, with multiple clicks required to get a start time or stop time, date, station number etc. (G. M., via email).

- We have published three sprinkler controllers in the past, in July 1992, January 1996 and February 2000. All of these can be regarded as obsolete. None had the programming and other features you would want.

In the light of the relatively cheap systems now available, it is not likely that we would devote the resources need to produce a new design.

Driving A 120V Motor With The Induction Motor Speed Controller

I live in the USA and wish to use your 1.5kW Induction Motor Speed Controller (SILICON CHIP, April, May & December 2012) to drive a 120V 60Hz motor. Can I modify it to take 120V 60Hz as the input? (M. M., via email).

- The short answer is yes but there are several approaches you could take. First, you could use the 120VAC from your house circuit with the controller and that would result in a DC rail of about 160V and you could then control a standard 120V 60Hz motor. However, you would need to remove one 620kΩ resistor from the rail monitoring divider associated with pin 5 of IC2a.

You would also have to make sure that you used 120V transformers for T1 & T2.

Secondly, it would be quite straightforward to power the Induction Motor Speed Controller from 220VAC 60Hz (two phase in the USA) to run a 220VAC 60Hz single-phase motor or a 3-phase 400VAC motor.

Similarly, if you want to use a 120VAC input it should also be possible to modify the input bridge rectifier to a voltage-doubler rectifier (with two diodes and two capacitors) to give an internal 325V DC rail and thereby again run a 220VAC 60Hz motor (but with limited power).

Again, if you did this, you would also have to make sure that you used 120V transformers for T1 & T2.

We must emphasise though that we have not built or tested any 120VAC version of the unit. Finally, if you want to control a 120VAC motor, you still have a limitation on the current that can be controlled and that is 10A. That means that a 120V motor would be limited to 750W or about one horsepower.

Questions on the Frequency Switch

I have built your Frequency Switch project (SILICON CHIP, June 2007) with the intention of using it to latch on a certain male vocal "car flogger" radio advert. What is the minimum input signal voltage, frequency and trigger time required for a reliable unit please? I had intended to source the signal from across a loudspeaker voice coil, if that is not too low an impedance. (R. N., via email).

- The input threshold is typically 25mV above or below the -IN voltage on IC1. If you want to feed in an AC voltage, then connect the input via a capacitor (10μF) with the plus side to the input on the Frequency Switch. A 100kΩ resistor would be needed between pins 1 & 11 of IC1.

The output from the speaker would have sufficient level. Frequency for triggering is adjustable from 10Hz to 500Hz. For a higher frequency, change the 22nF capacitor at pin 2 of IC1 to a

Problem With High-Temperature Thermometer

After sorting some initial installation problems, my High-Temperature Thermometer (Silicon Chip, May 2012) is now working mostly as it should but I would like your input on a small problem. This relates to the cold junction compensation which seems to be working in reverse. The thermocouple is installed in an oven on a yacht as the temperature indication on the oven was 30°C out at 200°C. I have a thermocouple input on my multimeter as a reference.

The circuit board is in a cupboard next to the oven. With the oven in a closed position (overnight), the readout will rise from 20°C to 24°C in the morning, with the cupboard temperature at 16°C. As the day warms up, so does the cupboard and so the temperature readout comes down to match the true calibrated oven temperature.

It has me scratching my head as everything else is OK. I have replaced the LT1025, with the same result. I look forward to your comments. (I. N., via email).

- Your problem could be as simple as the leads of the thermocouple being connected the wrong way round. Try swapping the thermocouple connections to the digital thermometer to see if that solves it.

If this is not the problem, the LT1025 cold junction compensation IC can be tested by replacing the thermocouple with a short length of copper wire. The display will then show the ambient temperature. If the temperature readings seem wrong, check that the REF1 and REF2 voltages are correct at 2.49V each, as set using VR1 and VR2.

If you are using a LED display rather than an LCD, the temperature rise within the digital thermometer case (due to extra dissipation in REG1) will cause incorrect ambient readings.

lower value. For example, for a range of 20Hz to 1kHz, use a 10nF capacitor instead of 22nF.

Majestic would make a great subwoofer

When I first read the Majestic speaker project in your September 2014 issue, one the things that grabbed my attention most was the superb deep bass performance of the speakers, extending almost flat to 20Hz. The thought occurred to me in an instant how a single Majestic speaker would make a great subwoofer. It would not be as compact as many of the commercial subwoofers on the market, but much more efficient and with a very extended deep bass performance compared to most of them.

I am currently planning to build a single Majestic for initial use as a subwoofer but also allowing for later "conversion" to the full-range speaker. I will probably install the Celestion horn into the front baffle so that no later wood cutting will be required. Unless of course you can point out any reason why this would not be a good idea?

The main reason for my seemingly odd choice of turning the Majestic into a subwoofer rather than simply building a stereo Majestic set-up is that some time ago, after a long experience with HiFi systems built around large and expensive floor standing speakers, I found that the best configuration overall was a system based on a pair of small 2-way bookshelf speakers and a subwoofer.

The end result seems to offer as good if not better performance than a traditional large twin-speaker set up, with less bulk, much less cost and much greater flexibility. (P. T., via email).

- The Majestic would certainly make a very good subwoofer on its own and it would save space in a small listening room. It could be built into a coffee table in this role.

We would not team the Majestic with the Ultra-LD amplifier unless you need very loud sound levels. You only need about 10W to drive it to very loud levels and for this you could consider just building one channel of our Tiny Tim amplifier.

Infrasound Snooper circuit query

I'm a bit baffled by the 22Ω resistor in series with D1 from the plugpack connector in the Infrasound Snooper. It's shown on the circuit and in the parts list but is not mentioned in the description and is missing from the photographs.

Was it deemed unnecessary and linked underneath or did someone forget and not test it with a plugpack? (D. H., via email).

- We should have mentioned that resistor in the text. Essentially, all it does is to provide a small degree of HF filtering, in conjunction with the 220µF capacitor at the input of the 78L05 regulator.

Is battery life extender a scam?

I have seen this little device which clips over an AAA cell and supposedly it extends the cell life by up to eight times – see www.macworld.com/article/2928997/batteriser-is-a-250-gadget-that-extends-disposable-battery-life-by-800-percent.html#tk.nl_mwdail

If it was April 1st, I'd understand but are they onto something? (K. P., via email).

- The device appears to be legitimate and quite similar in principle to the LED torch driver module that we presented in the March 2013 issue, except that it is a lot smaller – see www.siliconchip.com.au/Issue/2013/March/AAA-Cell+LED+Torch+Driver

However, the claims for extension of cell life are ambitious in the extreme. Even claiming an effective doubling of life would be somewhat optimistic.

CDI for a Datsun 1600

I am currently building two of the new CDI units (Silicon Chip, December 2014 & January 2015) for my Datsun 1600. Currently, this is supercharged and runs a Haltech E6K computer and two Mazda MX5 wasted spark coils.

I recently had the car on the dyno again and measured the spark, which was lacking. I want to insert the new CDI units in place of the current igniters which are in the base of the coil units.

I have two questions which I would like your opinion on. First, the Haltech switches to ground to spark as it uses the spare injector coil drivers for this purpose. I am in two minds as to whether to alter the reluctor input on

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the CDI or put in an opto. It seems that quite a few after-market computers do this, whereas manufacturers tend to be the other way.

Second, I have read that old coils like these will not handle the extra work and voltage and I should replace them with two single coils (LS1) or four coils in total for this car. This particular issue seems to be glossed over. The Haltech has two outputs for spark ignition (IGN and ALT) in the sequential mode I use, so I am currently building two of the new CDI units. (B. H., via email).

- The reluctor input would be better to invert the Haltech low-to-fire switching sense. We doubt that the MX5 ignition coils would be short-lived when using the CDI. The CDI would actually cause the coils to heat up far less than compared to conventional inductive ignition where the

continued page 96

Notes & Errata

ASCII Video Terminal for the Micromite (July 2014): version 1.3 of the firmware has been released. This fixes two bugs, including one which caused USB data corruption in PAL composite video mode. Escape commands have also been added to turn the cursor on and off (see accompanying PDF file). The new firmware is available from both Geoff Graham's website (www.geoffg.net) and the SILICON CHIP website. It can be loaded onto units which have already been built using the USB bootloader via a Windows PC. Programmed chips supplied for this project will use this new firmware.

6-Digit Nixie Clock, Mk2 (February & March 2015): the daylight savings calculations were wrong for some locations and this resulted in daylight savings time being used year-round. A revised version of the firmware, 1910215C.hex, is available which fixes this. Future clocks kits will be supplied with the new firmware.

Users affected by this bug can set the manual time-zone override so that the unit shows the correct time or mail their PIC32 chip to our PO Box along with a return address for re-programming (be sure to note that the chip is for the Nixie Clock).

In addition, care is required when fitting LED1 and the super-capacitor. The IR LED supplied may have its flat side towards the anode, not the cathode (as is usually the case and as shown in Fig.4). Check by referring to the longer of its two leads, which will be the anode.

Also, as stated in the text, be sure to orientate the super-capacitor according to its polarity marking. Do not rely on the depiction in Fig.4 which may not be accurate for all super capacitors.

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coil is charged with current ready for firing. The voltage on the coil primary is very similar at around 300V to 360V whether CDI or inductive ignition, so that isn't a problem.

More information is available at www.worldphaco.net and www.worldphaco.net/uploads/CAPACITIVE_DISCHARGE_IGNITION_vs_MAGNETIC_DISCHARGE_IGNITION.pdf

Next Issue

The August 2015 issue of SILICON CHIP is due on sale in newsagents by Thursday 30th July.

Expect postal delivery of subscription copies in Australia between July 27th and August 7th.

How much power from Class-D amplifier?

If I power the two High Power Class-D amplifier modules (SILICON CHIP, November & December 2012) from a 300VA 30V + 30V transformer, what power output could I expect? (B. V., via email).

● Continuous power from each channel would be less than 150W into 4-ohm loudspeakers. For 8-ohm speakers, you could expect about 90W per channel. For normal program signals, you could expect up to 180W from each channel into 4-ohm loads. SC

WARNING!

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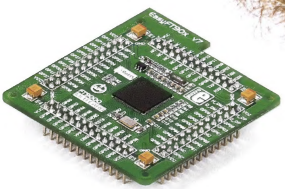

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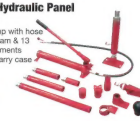

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- 240V - 15amp
- Duty cycle 10% @ 180A

~~$473.00~~
$429
(W240)

SHST-1.6HD
Shrinker Stretcher
- 1.6mm mild steel
- Shrinking dies
- Stretching dies

~~$539.00~~
$489
(S2266)

HEAVY DUTY

EWM-89
English Wheel
- 1.6mm mild steel
- 914mm throat
- Swivel roller head
- Includes 6 dies

~~$737.00~~
$679
(S2257)

HP-20
Workshop
Hydraulic Press
- 20 Tonne
- 110mm ram stroke
- Spring return ram

~~$339.90~~
$309
(P144)

HM-32
Mill Drill - Belt Drive
- 3MT spindle, 12 speeds
- (X) 540mm, (Y) 190mm, (Z) 410mm
- 820 x 240mm work table
- 2hp, 240V motor
- Includes drill chuck, tungsten tip face cutter & tilting vice

~~$1,749.00~~
$1,639
(M121)

MDS-H
Mill Drill Stand
~~$297.00~~
$249
(M135A)

AL-320G
Bench Lathe
- 320 x 600mm turning cap.
- 38mm bore 12 spindle speeds
- Geared headstock
- 1hp, 240V motor

~~$2,475.00~~
$2,335
(L141)

ST-320G
Lathe Stand
~~$297.00~~
$249
(L142)

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